PRODUCTION AND MANAGEMENT OF CAMELS

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PREFACE

The camel, without exaggeration, is the most ignored among the domestic ruminants in Pakistan. This is as much true in terms of lack of efforts to improve its care and productivity as it is in terms of lack of any planned research on it. Had it been an unproductive and a useless animal, its population would have gradually diminished, but it is the other way round. Its population is steadily growing. On papers, its population is being shown as stagnating, but most probably it is not so. On the international scene, there seems now a growing awakening in respect of the camel. At places, it has been termed as a ‘food security animal’.
In Pakistan too, some teaching institutions have taken an initiative and have incorporated “Camel Production” in their teaching courses. No doubt, it is a very timely step.
Scientists from Germany, England, India, Australia and UAE have published books on camel. These are, of course, good books but as usual their prices are prohibitive for our students, extension workers and even for teachers. Moreover, these books contain a little information about camels in Pakistan. Therefore, an easy-to-understand book on ‘Production and Management of Camels’ using a question-answer format, has been compiled. This should provide ready-made answers to so many questions simmering in the minds of students, teachers, researchers and extension specialists. It embodies about 400 questions along with their answers.
The book discusses the distribution of camels in different continents/countries, breeds and types of camels with cross reference to other species, nutritional physiology and reproductive management, the way camels adapt to hot arid environment, milk and meat production and work performance, practical management and training of camels, marketing, health care and some diseases, including valuable information on several other aspects. Camel breeds and camel raising practices in Pakistan have been adequately discussed.
We feel great pleasure in acknowledging the hard work done by so many researchers/authors/editors, whose published information has been used, mostly as such, in compiling the book under reference. Their efforts have been amply acknowledged in the text/tables/figures etc. It was beyond our means to individually contact them in this regard.
We are highly thankful to Akhter Saeed MD for providing us useful literature from abroad. We are equally thankful to Dr. Ghulam Muhammad, Chairman CMS, UAF, for his cooperation in providing pertinent literature. Ch Sikander Hayat and Nawaz Ahmed Sipra also deserve our heart-felt appreciation for helping us out of many problems pertinent to the publication of this book.
No book has ever been claimed to be perfect in all respects and so is this one. The readers are requested to convey in writing their suggestions about omissions/shortcomings noticed in this book. Their suggestions would not go unnoticed.

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FOREWORD

For a long time the camel has been the victim of disregard and deliberate neglect of scientists and development workers. However, the last about two decades have witnessed a resurgence of interest in this species. Most of the work to exploit the productive potential of the camel has been undertaken by those who come from such countries that do not even possess camels. I think this should be more than enough to make us realize our responsibility towards a multipurpose domestic animal species, of which this country has a sizeable population. We need to investigate its peculiarities and exploit its potential especially in terms of milk and meat production and to explore the possibility of increased export of live camels to several Middle East countries. Presently some of these countries are importing camels from Australia.
To strengthen the possibility of implementing such plans, we must be equipped with recent knowledge about various aspects of camels. In this connection and as an animal scientist myself, I feel pleasure to mention that a book with the title ‘Production and Management of Camels’ has been brought out by experienced teachers/researchers, which should suffice to meet the needs as mentioned above. The contents of this book make me believe that it should be as much helpful for students, teachers and research workers as for extension specialists.

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PART – I

Part – I includes:

- *Introduction*
- *Breeds and Types*
- *Feeding and Nutrition*
- *Breeding and Reproductive Management*
- *Productivity and Performance*

INTRODUCTION

Q. Is the camel a monogastric or a polygastric animal?

The camel is a polygastric animal, but not a true ruminant. True ruminants have four-compartment stomach, whereas there are three compartments in the camel stomach. Since after feeding, the camel also ruminates, therefore, it is called a special ruminant or sometimes as a pseudoruminant.

Q. Write down the synonyms for the one-humped camel.

The term Arabian camel and dromedary exactly mean the same as one-humped camel.

Q. What is the probable origin of the word camel?

The word camel is said to have been derived from the Greek word ‘Kremal’ or from the Sanskrit word ‘Kreluk’. The latter means ‘throw away legs’ and thus appears to make sense since a running camel seems as if it has thrown out its legs in the air with little control over them (Isani and Baloch, 2000).

Q. On what basis the two-humped camel is named as Bactrian?

Probably the name ‘Bactrian’ was derived from the word ‘Bactria’, the old name of the present day Turkmenistan in Central Asia.

Q. Write a note on old world and new world camels.

Old world camels belong to the genus *Camelus*. They are found in deserts/plains. They are bigger in body size and weight. They have either one or two humps. Those having two humps are mostly found in cold mountainous regions such as parts of Afghanistan, China and Mongolia. New world camels are placed in genus Lama. They are much smaller in size and body weight. They are found in areas located at much higher altitudes. They are humpless. Their habitat is by and large restricted to South America and are thus also called South American camels.

Q. Do the llamoids have hump like that of dromedaries?

Researchers believe that llamoids migrated to South America via North America and that probably they lost their humps during the course of evolution in South America. The modern one-humped camel is said to have evolved from the Bactrian camel. Some embryologists also support this idea on the basis that the dromedary has two humps in its embryonic stage, which are fused into one hump before birth.

Q. What, in general, is the socio-economic importance of the dromedary?

Precise data to assess the real socio-economic importance of the dromedary are not available. However, during the last about two decades, some academic and research institutions and international and national development agencies of a few countries have undertaken studies in this regard. Most of these studies have termed the camel as an animal of great socio-economic importance in large tracts of the third would. Two-thirds of the world’s camels are in Africa. Of these, over 5 million constitute a giant milking herd in Somalia and some bordering areas of neighbouring countries. Elsewhere many are still engaged in transport of salt, fuel wood, agricultural produce and household goods, and the rest are involved, sometimes with other animals, in the subsistence of both sedentary and nomadic human groups. Camels may still be seen being used in varying

types of agricultural operations and drawing wheeled vehicles for intracity transport of goods in several areas of Indo-Pakistan subcontinent, including the streets of cities like Karachi, Multan and Faisalabad. In addition to power and transport, camels provide milk and meat not only in very arid regions but also in several urban areas in many countries. It has the ability to withstand the adverse effects of severe drought. Compared to small and large true ruminants, mortality rate in adult camels is very low in the event of drought conditions.

It has been established that at least in the medium term, adoption of better camel husbandry practices can improve the life of African nomads who largely earn their living through camel raising. There are a lot of predictions in the air about increased global warming, the camel probably would be the most favoured animal in that scenario. In Australia, the Central Australian Camel Industry Association is currently studying the possibility of moderate to large scale meat production becoming a commercially viable enterprise. Production will be based initially on the large existing feral camel population. The market possibilities are for a local and export trade worth $A15 million by the year 2005 (Manefield and Tinson, 1997).

In the wealthy Arabian Gulf states, notably UAE and Qatar, a thriving camel industry exists which is based on racing. The amount of money being turned over and the number of people involved many of them expatriates, justifies the use of the term ‘camel racing industry’. At important annual race meetings, it is not uncommon for the value of trophies, usually vehicles ranging from top of the range Mercedes, through Range Rovers to GMC pick ups, to be around US$3M. The wealthy owners usually give these trophies to the trainers who are, in turn, expected to express gratitude to their staff with more than words.

It is not out of place but in a sense an unpalatable suggestion that to improve, in general, the present plight of the camel in terms of its reproductive performance and milk and meat production, if it is made mandatory that at least 10 to 15% of the total annual prize money to be paid to the winners is deposited, as a cess for Camel Improvement, with the state government where camel races are held. The state government then should allocate, under an approved plan, part of the money collected for the purpose, to two institutions, one in Africa (e.g. Sudan) and another in Asia (e.g. Pakistan), for the phased improvement of the one-humped camel. Such a development programme shall have to be persistently persued for about 15 to 20 years. The outcome of these efforts, including the progress and problems, should be annually reviewed. The aims and objectives should be scientifically weighed and precisely defined. Such a project if successfully implemented, can ultimately benefit millions of people in Africa and Asia whose livelihood is linked with the camel. It is, however, really heartening that already research on some aspects of camel production is underway in the UAE U and the Scientific Centre for Racing Camels.

Camels may be bred by common folk, trained successfully for racing, can be purchased by members of the royal families and wealthy businessmen. Scouts may spot fast camels from places as far away as Sudan. It is said that the top price paid for a racing camel was 15 million dirhams (3.65 dhs = US$ 1), while the price for good race winners is 2 to 6

million dirhams. Nondescript camels in the general market bring 2 to 3 thousand dirhams each for males and 4 to 6 thousand dirhams each for females. Camels represent wealth in other places as well. In Pakistan, an adult camel is worth about 30 to 35 thousand rupees and good specimens may fetch 50 thousand rupees each (58 rupees = US$ 1). Similarly, in India they are worth 18 to 25 thousand rupees each (42 rupees = US$ 1). In Australia, depending upon the degree of domestication and age, a camel is worth $A 700 to $A 2000 ($A 1.40 = US$ 1) (Manefield and Tinson, 1997).

Q. Discuss the contribution of the camel to the agrarian economy of Pakistan.

The camel contributes to the agrarian economy of Pakistan in various ways, but precise data in this regard are not available. The contribution of the camel even in terms of milk and meat production does not seem to have been properly assessed.

The people residing in remote desert areas and nomads consume fresh raw or soured milk (a sort of yogurt). The nutrient contents of the camel milk are as good or even better than that of the cow milk. Of great relevance for human nutrition in desert arid areas is its high vitamin C content ranging between 29 and 36 mg/litre milk, which amounts to three times the level of cow's milk and one and a half times as much as in human milk. Almost around all major cities in Pakistan mobile camel dairies are found. The nomad camel keeping families keep on moving from one suburb locality of the city to another and sell camel milk there. The reported milk yield ranges between 900 and 4000 litres in a lactation period of 250 to more than 500 days. The average daily yield under different management systems is reported to vary from 3 to 8 litres. The females are milked twice to four times a day in Pakistan. According to a very modest estimate, the camel milk annually produced in this country is 0.24 million tons valued at Rs. 2.4 billion.

The camel meat is largely consumed in remote rural and desert areas, but cities are no exception. In a city like Karachi, about 10 camels are slaughtered on each meat day. The carcass weight of a camel reared under low input varies from 180 to 300 kg. The dressing percentage ranges from 46 to 50. A very moderate estimate indicates that over 5000 tons of camel meat is being annually produced in Pakistan valued at Rs. 250 million. The meat of camel slaughtered at the age of 3 to 4 years tastes like beef, but most of the people here have not developed taste for it. However, at many meat shops it is sold mixed with buffalo and cattle meat mostly in minced form. The number of people who like camel for sacrificial slaughter on Eid-ul-Azha is gradually increasing every year. Mainly young animals are preferred for slaughter on the occasion of Eid.

Camels serve as a source of power for drawing water from wells, for working mini oil extraction (from oil seeds) mills, grinding of wheat, corn, gram and for sugarcane crushing. They provide energy for ploughing land, pulling cart for transportation of goods as well as people. In addition, baggage camels comfortably carry loads up to 300 kg to distant places at a rate of 30 km/day. Thus they are a comparatively cheaper source of power for various agricultural operations and to meet allied transportation needs of small farmers and nomads.

Camels raised and trained as riding/racing animals, or for dancing and wrestling or those trained to perform acrobatics, fetch two to four times higher prices than the normal prices of common camels. Similarly, camels raised to be sold for sacrificial slaughter on Eid-ul-

Azha, fetch on average, no less than Rs. 20 to 30 thousand per animal. With a little more than usual input in feeding and care of such animals, profit margin can be substantially enhanced. These facts tend to suggest that the camel can be of immense help to improve the economy of those involved in raising it, provided they supplement their traditional management systems with modern husbandry practices and health care of their animals.

Native camels also indirectly contribute to the economy by surviving under pastoralists/nomads or small farmer's management systems with surprisingly low inputs mostly in the difficult and drought stricken arid areas and mountainous regions where long term survival of other livestock does not seem possible. Also, they do not compete with other livestock for their nutritive requirements since most of the time they browse top of trees and shrubs.

Q. Discuss in detail economic potential of the camel.

The camel (dromedary) is an important livestock species uniquely adapted to hot and arid environments. It produces milk, meat, hair, some wool, hides, serves as a beast of burden and used for riding and as a draft animal for agriculture and short-distance transport. The majority of camels in Pakistan are kept by migratory pastoralists in subsistence production systems except those kept in irrigated areas by farmers and a small number used for pulling camel carts in cities. Not all farmers keep a camel but most often maintaining one camel suffices for various agricultural operations of a farmer. Off-take of live animals for sale as slaughter stock is much less as compared to that of sheep, goat, cattle and buffaloes. However, apart from routine slaughter, on festive and religious occasions such as Eid-ul-Azha, hundreds of people would slaughter camels and consume their meat.

The importance of the camel as a long-distance transport animal has been gradually declining but this does not minimize its importance since various studies tend to show the camel as an emerging source of increased meat and milk production, more particularly milk. With increasing human population and simultaneous increase in gap between supply of meat and milk, there is urgent need to develop previously marginal resources such as the semi-arid and arid rangelands and optimize their utilization through appropriate livestock production systems, of which camel production is certainly complementary and the most suitable one.

Table 1. Numbers of domestic ruminants and camels in the world and Pakistan (million head)

Species	World	Pakistan
Buffalo	165	28.4
Cattle	1350	23.3
Sheep	1058	24.6
Goat	720	52.8
Camel	18.23	1.2

Source: FAO (2000) and Anonymous (2002-03) except for camel.

From a global perspective, the economic significance of camel production is minimal as the comparison of livestock numbers (Table 1) clearly shows. Even for Pakistan alone the

economic potential of the camel, judged by numbers only, remains limited in comparison to the other livestock species. Certainly the importance of camel production becomes more evident if one considers the arid areas of Balochistan, Sindh, Punjab and NWFP alone where camels make a considerable part of the local livestock. Unfortunately it is very difficult to evaluate the economic significance of camel production by conventional parameters such as cash flow analysis, gross margin calculation etc.

Q. Discuss in general, the present status of camel production.

A growing awareness that the camel can serve as a major food (milk and meat) producer in semi-arid and arid areas has helped change its image from 'ship of the desert' to 'a food security animal'. The last three decades have also seen an increased scientific interest in all matters concerning utilization and management of arid lands and with it is a substantial number of scientific publications on the camel. According to Wilson (1989) most of these publications covered veterinary aspects, anatomy and general and reproductive physiology. Studies on feeding and nutrition, camel management, production systems, productivity and economics are very rare. Most of the published work is either based on small number of animals, short observation periods, one time surveys and interviews or estimates. Since camel production is usually a migratory system and it is practised mainly in remote areas with harsh living conditions, poor infrastructures and low economic potential, therefore such studies would be difficult, time consuming and expensive. As a consequence not a single long-term, methodical study of any aspect of camel productivity under such conditions has been published. Schwartz and Dioli (1992) stated that research on camels conducted during the past two decades has had very little, if any, impact on the promotion and development of camel production. Numerous symposia and learned conferences on various aspects of the camel have been held in recent years, three bibliographies on camel research have appeared, international and national institutions have established coordinating units, produced newsletters and commissioned consultancies. However, there is still not a single project or programme in the field focusing mainly on the improvement of practical camel production. Considerable effort is required to facilitate development and implementation of feasible and sustainable programmes to improve the present camel production. As suggested by Schwartz and Dioli (1992), interventions are conceivable on the biological and ecological system level, the managerial and economic level, the institutional and legal level and probably the most important is the political level.

Q. Write a note on percentage distribution of camels in Africa and Asia.

There are an estimated 18.58 million camels in the world. Of these, 16.2 million are one-humped camels. More than 80% of all Arabian camels are found in Africa. East Africa contains about 63% of all old world Camelidae. Somalia and Sudan account for 70% of camels in Africa; Ethiopia, Chad and Kenya contain a further 12%. In addition to these countries, Mauritania, Niger and Mali have sizeable populations as do Maghreb countries of Algeria, Morocco and Tunisia. In Asia about 70% of dromedaries are found in India and Pakistan.

Q. Give an estimate of world population of camels and their distribution in various continents.

There are about 18.58 million camels in the world. Africa has the highest number (13.62 million) followed by Asia (4.76 million) and Australia (0.2 million). Elsewhere, the number of camels is highly negligible.

Q. Give the total population of camels in Pakistan and its percentage distribution provincewise.

Pakistan possesses1.2 million camels (FAO, 2000). Balochistan province has the largest population (36.43%) followed by Punjab (33.51%), Sindh (22.76%) and NWFP (7.30%) (Isani and Baloch, 2000).

Q. Discuss the relationship between environmental influences and world distribution of camels.

With few exceptions one-humped camels are found in areas where rainfall is low and occurs in a relatively short period followed by a long hot dry spell of several months. Thus their normal range is the African and Asian tropical and subtropical dry areas, including the deserts of northern Africa, parts of western Asia and the Indo-Pakistan subcontinent. The northern and western edges of dromedary's in Africa are Mediterranean sea and the Atlantic ocean. In Africa, the limit extends from the Senegal coast through central Mali to the south of Niger. In Chad and Sudan, the southern limit in recent years has been gradually pushed southwards. However, the presence of tsetse and other biting flies has restricted the distribution of the camel further south. In eastern Africa, the arid conditions of the Red Sea coast, the Gulf of Aden and the hinterland of Indian ocean coast are favourable to the camel. In Asia, dromedaries extend northwards into Turkey, the southern parts of the former Soviet Union and Afghanistan where their range overlaps with that of the Bactrian camel. The main area of distribution of Bactrian camels is the deserts of Inner and Central Asia (from western Kazakhstan to Mongolia and northern China) with a continental climate comprising very long and very cold winters and short hot summers (Wilson, 1998).

Q. Do social and cultural factors have any relevance to the distribution of camels in various regions?

Camels are the domestic animals of nomads. The nomadic owners are obliged to take their camels with them to assure their basic needs of milk, meat and transport. The greatest cultural impact on the recent distribution of camels was the advent of Islam. As Arabs spread the message of God, they took their one-humped camels with them, extending its range northward and eastward in Asia and westward along the Mediterranean sea. Until the arrival of motorized transport and the monetarisation of desert economies, camels remained almost the only beast of burden and personal transport animal in the area to which they were adapted. The internal combustion engine and the wider distribution of money have considerably affected the transport role of the camel, but they have had much less effect on its cultural relevance. This and its continuing economic significance are evident from the several countries that issue currency with the camel as a motif (Wilson, 1998).

Q. What is the recent view about the evolution of camelids?

There are different views in this regard. The most recent, however, is that all the camelids evolved in North America. The Tylopoda were recognizable in the Middle Eocene of 50

million years ago and well differentiated some 10 million years later. Early camels were probably small but some subfamilies comprised genera in which animals were very big, as indicated by their genus names such as Megatylopus, Megacamelus, Gigantocamelus and Titanotylopus. Camels migrated across the land bridge (which is now the Bering Strait between Alaska and Russia) from North America to Asia. Some species subsequently reached Africa and Europe. Other species migrated into South America. These migrations probably occurred between three and four million years ago. When camels disappeared from North America is not exactly known.

Q. Discuss the domestication of camel.

The genus *Camelus* was probably among the last of the major domestic species to be put to regular use by man. There is a little direct evidence for an exact time of domestication, mainly because the camel has changed relatively little as a result of selection and, whereas it is possible at archaeological sites to observe the changes in other species, this is not the case for camels. Since the early camel owners were nomadic, they left few permanent mementoes of their presence. The most likely time of domestication, however, is about 4000 years BP (before present). Southern Arabia (which is now the north eastern part of Yemen and the west of Oman) is the most likely area. There is, indeed, little firm evidence of true domestication until about 2500 BP.

There is more direct evidence of domestication of the South American camelids than of the old world ones. The archaeological evidence suggests that llama and alpaca were domesticated at very high altitudes of 4000 to 5000 m in the Andes of southern Peru and western Bolivia. An approximate time of first domestication would be about 6000 years BP. This period has been based on changes in the type of molar teeth and the increasing numbers of bones of young as compared to old animals found at archaeological sites.

Q. Discuss the taxonomy of the camel.

Both of the old world and new world camels belong to the subfamily Camelinae of the family Camelidae in the suborder Tylopoda of the order Artiodactyla. Camels are even-toed ungulates but differ from most others of their order in having soft, padded feet. They are generally referred to as special ruminants or occasionally as pseudoruminants because of their ruminating habits. Camels do not belong to the same suborder as the other major meat and milk producing domestic herbivores. It is now customary to place old world camels in genus *Camelus* and new world or South American camels in genus *Lama*. Within *Camelus* two species are generally accepted: *C. dromedarius*, the one-humped or Arabian camel or dromedary; and *C. bactrianus*, the Bactrian camel or two-humped camel. Biologically, the species division is not correct, as the two freely interbreed in either direction and produce fertile offspring. There are four species of new world Camelidae of which two are domesticated and two wild. The llama, *L. glama*, is used mainly as a pack animal, while the alpaca, *L. pacos*, is primarily a producer of high quality fibre. The two wild species are the guanaco, *L. guanicoe* and the vicuna, *L. vicugna*. All the South American Camelids have a very similar karyotype with the same number of chromosomes (2n = 74), which is identical to that of the old world camels.

Q. Give a comprehensive list of the distinguishing features of the camel.

i) It has exceptional tolerance to heat and deprivation of water. The physiological characteristics assist the camel in the conservation of water.
ii) Being a homeotherm, the camel can vary its normal body temperature over a considerable range.
iii) The camel can concentrate its urine and recirculate and reutilize urinary nitrogen when it is deprived of water. Moisture in faecal balls is also considerably reduced.
iv) Male camels exhibit little sexual activity outside a specific rutting season.
v) During rutting, the soft palate of the camel increases in length. It then hangs out of mouth on one side and is called ‘Dulaa’.
vi) Camel prefers most of the time to browse top of bushes and trees rather than graze because of its flexible long neck, long legs and cleft upper lip.
vii) In contrast to other ruminants, camel is hornless and has no gall bladder.
viii) It has almost no competition for feed with other animals.
ix) It has unique ability to walk through long stretches of desert and hence called ‘the ship of desert’.
x) Dentition differs from other ruminants in that there is a pair of well developed and pointed canine teeth in each jaw.
xi) There are long conical papillae on inside of the cheeks directed backwards, thus the camel can browse at the thorny plants without any harm. The canine teeth help the camel to take into grip the twigs and remove them from the trees.
xii) The camel is a hardy animal, comparatively eats less, goes into so called sleep for short intervals and possesses a long lasting memory. It is said that it remembers any extraordinary harsh treatment given to it such as heavy beating by its caretaker or the rider and is said to take revenge at an appropriate time.

Q. What are the major constraints to higher productivity of camel herds?

Statistics on camel numbers, population dynamics and levels of production are sketchy at best and long-term performance records in larger herds are not available. However, general field observations and a few available surveys indicate that slow reproduction rate, low life-time performance of female breeders and high calf mortality are the major constraints in improving productivity of camel.

Q. Write down the principal physical characteristics of one-humped riding and pack camels.

Physical Characteristics of Riding Camels: Slender animals with a long and level shoulder, head small with a fine muzzle, moderate lips, ears small and set close together, eyes alert, lower jaw deep below the eye; the neck is fine and supple and joined low down to the trunk; a smallish hump; the shoulder long and fine, the chest very deep, abdomen tucked in, ribs well sprung and terminating not far from the pelvic bone; the fore legs set close together, straight, no brushing at the knees, feet not turned out, the hind legs straight, with no cow hocks; the quarters well muscled and the tail set high; the feet medium sized, the pace easy and tireless; liveweight rarely exceeds 400 and 550 kg in females and males respectively; the animal needs not to be driven; the skin fine and supple.

Baggage Camels: They should not have faults inadmissible in riding camels. They are much 'coarser' animals, with heavier head and neck, with fore- and hind quarters having more balanced appearance, shorter legs, heavier bone and larger feet. Hump more pronounced in well fed animals. Their pace slower and shorter than that of the riding types but equally tireless. Liveweights of 600 kg in females and 750 kg in males are not uncommon. Apart from riding and pack animals, another way to classify one-humped camels relates to location, allowing camels to be classed as lowland or mountain types (Table 2).

Q. Describe the salient physical characteristics of one-humped lowland and mountain camels.

Table 2. Salient physical characteristics of one-humped lowland and mountain camels

Characteristic	Camel type	
	Lowland	**Mountain**
Overall size	Large	small
Withers height (m)	1.93-2.13	1.82 – 1.96
Conformation	Rangy	compact
Neck and legs	Long	short
Hindquarters	Light, sloping	well developed
Feet	Oval, usually soft	round, hard
Coat	Short, fine	long, coarse

Source: Wilson (1998).

Q. Write a note on camels as a source of recreation.

Many people have a desire to ride a camel. A few actually own pet riding camels. Some want to ride for a brief period only and others to caravan overnight into the desert and experience a little camel culture. The senior author himself enjoyed a few camel rides and the longest very comfortable ride was 60 km through a desert in two days. Camel riding can be witnessed in Central Australia and in the deserts of Cholistan, Tharparkar, Rajisthan and on the beach in Karachi where beautifully decorated camels make their riders believe that camel ride is no less comfortable. Visitors to the zoo enjoy the structure and stature of the one-humped and the two-humped camels kept there as show animals. Organised camel racing as in the UAE and Qatar, has become a very popular sport involving thousands of camels (about 15000 racing camels in UAE alone) (Chaudhary and Akbar, 2000) as well as thousands of camel owners, trainers and their staff and spectators. It is thus not only a popular recreation but a source of living for a very large number of people. Apart from organized racing, there are camel races throughout the camel range, which are of a more light hearted and spontaneous nature. There is also widespread involvement of the camel in local and international tourism.

Apart from riding, camel troops in various places take part in festivals and exhibitions, where dancing camels attract large crowds. The camel troopers of the Rangers of Pakistan and of Border Security Force of India perform an elaborate musical ride and other entertaining evolutions. Also in Rajisthan, at the annual Pushker Festival, camel

wrestling is an important event among others. Trained bull camels take part in wrestling in a ring of spectators. No doubt, the camel is involved in many other recreational activities that differ in different regions (Manefield and Tinson, 1997).

Q. Discuss the temperament of one-humped camel.

Depending upon the individual variations (what may be called as inherited personality factors) and the conditioning influences of training, some camels become very docile and tractable, while others never seem to lose the habit of making defensive threats in response to routine handling. Opinions differ on the extent to which camels express curiosity. Generally they do investigate new objects by close sniffing and mouthing. They are often described as patient, docile and tolerably stupid. At times they can be quite obstinate. Some of them never learn to couch or rise willingly to a command or some other cue. Some force or threat is necessary and still they may continue to vocally complain during their whole working life. The more handling they receive, the more tractable they appear to become. Black camels are said to be untrustworthy and unpredictable. There are stories of human skulls being crushed and arms being severed. It should be the practice to wear hard safety type hat when handling strange camels.

Strikes and kicks can be very swift and dangerous because of the two horny claws on each foot. Striking with the forelimbs is often performed as part of a rearing jumping action while on the move. With the hind leg the camel can kick to its own shoulder in swinging sidewards and kick forcefully rearwards. They are able to deliver a strong sweeping kick while in sternal recumbency. The camel is also capable of delivering quite a forceful, backward kick with the front leg. Wild camels in open country will run away while they can, but may be very aggressive when confined. They may appear to take a dislike to a particular person and rush past a closer person to attack the targeted one. Generally, however, they settle down soon and accept new surroundings, confinement and the presence of humans.

It is wise to regard all strange camels as potentially dangerous, test them cautiously and trust them only when they are known to be trustworthy. Never forget that bulls in rut often show behaviour that is more aggressive than at other times. To become a good camel handler, one must behave tactfully and seek to acquire some knowledge of 'camelology' (Manefield and Tinson, 1997).

Q. Write a detailed note on endurance capability of Arabian camels.

The chosen gait of the one-humped camel on free range is a leisurely but almost a continuous walk. When walking the camel covers about 4 km/hour. They have often been tracked to cover >50 km during a day's feeding, but 30 km is very common.

Very young camels exhibit vigorous, spontaneous play, including some running and jumping. By 2 to 3 weeks age they are involved in playgroups similar to those formed by lambs, kids and buffalo/cow calves. These groups remain almost together between feeds. Mature camels will hasten towards a feed supply, usually at a jog, but sometimes at a gleeful canter or gallop. Some running and chasing may be exhibited by males in rut. Females will sometimes chase and show male sexual behaviour. Other than when being forced to faster gaits, this is about the limits of a camel's natural tendency to exercise. When forced, the camel's feats of endurance and strength can be remarkable. Mixed

camel/horse races over distances of 30 km, have been held in the UAE. The horses have won these races but generally have suffered greater post race distress than have the camels, but some have stopped the race and refused to go on. Judged by its physical equipment, the camel would be expected to be an endurance rather than a speed animal. During the first kilometer or so of an 8 to 10 km camel race, it will reach a speed of about 45 km/hour. In the UAE, the best speeds recorded over these full distances are 34.7 km/hour for 8 km and 33.8 km/hour for 10 km. In outback Australia, a race between a camel and a horse took place from Bourke to Wanaaring, a distance of 160 km. The journey was completed in one day, between sunrise and sunset, with the horse winning by a small margin. Overnight the horse died. Next morning the camel set out to return to Bourke. In 1874, the explorer Giles marched 350 km across south Australian desert in 40°C temperature, with two horses and three camels. The horses were given water but did not survive the trip. The camels completed the march in 8 days without water. Giles later marched 480 km in 17 days across the Victoria desert. The camels completed the march without difficulty. There are numerous accounts of men surviving in the desert by killing a camel and drinking the liquid from its stomach.

The camel's relatively low oxygen uptake has surprised the workers in the field of exercise physiology. Maximum oxygen uptake has been measured at 55 to 65 ml/kg/min for camels, about 120 to 175 for horses and dogs, and 30 to 80 for man. At speeds of 6m/sec, the camel's cost of locomotion is 50% that of the horse and 40% that of man. It is postulated that the camel's athletic ability may result from its having relatively long legs and efficiency of locomotion. The rolling pacing gait of the camel has a significantly smaller vertical lift component than that of the galloping horse. The camel has been described as an animal capable of accomplishing great feats of endurance in extreme environmental conditions because of its ability to employ unique biochemical and biomechanical mechanisms (Manefield and Tinson, 1997).

Q. Briefly describe the morphology of the dromedary.

The dromedary or one-humped camel is a large special ruminant characterised by a long, fine, low set neck and a hump of a varying size over the center of the thoracolumbar region. The mature weight and height at the withers respectively are 400 to 700 kg and 2.2 meters. Female and male racing camels aged 4 to 6 years in the UAE, on average weigh 350 to 450 kg and 400 to 480 kg respectively. The head is carried high in an 'aloof' style with the anterior nasal plane almost horizontal. At eye level this plane is dished and a nearly Roman nose is the norm lower down. Large supra-orbital process produces a beetle browed (prominent brows) appearance. In baggage types the head is plainer and it is more refined in riding animals. The upper lip is cleft and overhanging the lower one. The external nares slit-like and capable of being closed. The ears are small and roundish. The eyes are soft and calf-like in appearance. The eyelids are equipped with relatively long lashes (Figures 1 and 2).

The coat colour varies from occasional almost white through reds, rusts, fawns to almost black. Two coloured pied camels are also found in certain areas. Long seasonally deciduous wool occurs on the back and upper body sides.

The body has a deep, narrow chest and a relatively small abdominal waist. The croup slopes at 45 degrees or more to the horizontal. The legs are long and fine. The thoracic limbs support about 65% of the standing weight and are slightly more robust than the pelvic limbs, which may be relatively straight. Below the fetlock, the skeletal structure is biped and the termination is a pair of horny claws on each foot. The integument is common and the ground surface is a single almost circular keratinised pad. Keratinised pads are also present on the knees, elbows, stifles, hocks and sternum. The pad underneath the sternum is called the pedestal. This may be 7 to 8 cm thick vertically and keeps the animal's body clear of the ground when it adopts sternal recumbency. The footpads of newly born camels are quite soft and delicate. They should not be forced to travel over terrain with sharp objects until their pads have hardened.

The tail hardly reaches stifle and has about 8 cm long hairs that are restricted to the sides and the tip of the tail. The udder is four quartered and situated between the hindlegs. The scrotum is situated high against the perineum. The preputial opening is directed backwards when the penis is relaxed (Manefield and Tinson, 1997).

Q. What is meant by camel pads? What is their significance and how do they form?

The camel is equipped with some keratinised skin areas on its body generally referred to as pads. These are secreted from a vascular membrane that covers a foundation of fibrocartilage. These pads enable the camel to rest for prolonged periods in sternal recumbency even on fairly abrasive surface. There is one pad on each knee, one on each elbow, one on each stifle, one on each hock and a large one on the sternum, called the pedestal. All except the sternal pad are barely proud of the skin and the hock pads may be insignificant on some camels. The sternal pad is backed by fibrous tissue and usually protrudes 7 to 8 cm below the ventral line of the chest in the standing animal. In couched position, unless the abdomen is very full, the only parts in contact with the ground are the pads and the limbs distal to the carpus and the tarsus. The anterior, dependent part of the prepuce in the male may also touch the ground.

The pads are not fully developed in the neonate and are covered with hair, which wear off during the first few months of life as keratinisation occurs. This occurs first on the knees at 5 to 8 weeks and then soon after on the elbows. The pedestal may show some keratinisation at 8 weeks and is usually completely keratinised by 12 weeks. The development of stifle pads also starts between 9 to 12 weeks. All pads except those of hocks are well developed by 10 to 12 months age. It takes 3 to 4 years when hock pads develop and are usually smaller, even absent, in some camels. The knee pads, although first to keratinise, are often the smallest. Camels from places such as stony desert as in Australia, develop large, thicker pads earlier than camels from sandy deserts. This holds true for their footpads as well (Manefield and Tinson, 1997).

Q. Write a descriptive note on the hump of an Arabian camel.

Since the Arabian camel is an one-humped animal, the discussion on hump will be restricted to one hump. The hump is the major storage place for subcutaneous fat. There is no internal bony support and the hump is covered by relatively elastic skin and reinforced by fibrous tissue. The fibrous tissue is mostly in the anterior part and where the hump rests on the vertebrae. Here the fibrous tissue of the hump merges with the supraspinous ligament. The hump is thus anchored to the vertebrae by aponeurosis. The size of the hump is usually a good indicator of a camel's condition. The hump is taller and extends down the sides of a fat camel. In contrast, the hump is highly reduced in size and so depleted as to tend to fall over to one side in a lean thin animal. Localising of subcutaneous fat in the hump indirectly assists the camel with cooling. Except in very fat animals, an appreciable amount of diffusely distributed subcutaneous fat is rarely seen in camels.

For too long it was though that the metabolism of fat from the hump was a major source of the camel survival for many days without water intake. This has since been shown to be a fallacy. It was experimentally shown that fully fed camels were dehydrated for over 10 days. They lost about 25% of their body weight but the height, length and circumference of the hump did not change. The fat in the hump is mainly a reserve of energy for times of primary shortage or secondary need such as illness. Camel fat is generally white and soft. When rendered down 96% of the hump weight is recovered as a very clear oil, which is said to be highly regarded for traditional Chinese cooking. The hump fat is about 61.7% saturated (palmitic 37.9% and stearic 14.5%) fatty acids and 38.3% unsaturated (oleic 30.9% and linoleic 3%). The cholesterol content is about 87 mg/100 g.

Ruptured aponeurosis should be suspected whenever a large lump is seen to be unstable and carried to one side. This may be due to rough treatment of very fat camels with a massively domed hump. Later, when the hump fat has been utilized in time of food shortage, the hump will be seen draped to one side and flopping about like a balloon half filled with water. The hump is considered by some a good site for subcutaneous injection.

Q. Describe general guidelines for selecting camels.

Camels sold in markets are mostly not the best animals, therefore, it is advisable to go out to the herd where it is grazing. Valuable milking animals are invariably not used to carry loads, thus there should be no signs that the animal has been used in this way. Only strong, healthy animals, having no obvious faults should be selected. Handle the animal twice or thrice to cheek its temperament.

Head: Check for blindness and defects in both eyes. Examine the teeth to determine the age of the animal. Press your hand on the animal's cheeks to make sure that all the teeth are present. Also, see that the animal is no under- or overshot.

Legs: These should be straight. Watch for limping or other problems when the camel is walking, sitting down or getting up.

Front Legs: There should be ample space between the chest and the front legs. The legs should not rub against the chest pad and the knees should not rub against each other. The fetlocks should be straight. Examine the knees for sores or scars, which show that the

camel has been restrained with a rope around its front legs. This partially indicates that it was not considered useful during the rut and was used for work instead.

Rear Legs: The hock joints should not be too close to each other while the camel is standing, and should not touch when it walks. Also, see that the Achilles tendon is not swollen or painful. This may show that the camel has been used too early and too much as a pack animal.

Feet: Check the soles of the feet for wounds or bruises.

Chest: A narrow chest can show that the camel was malnourshid as a young calf. There should be no sores or abnormal growths on the chest pad.

Hump: It should not be very big. A very big hump shows that a male is a poor breeder (probably no rut) and that a female is sterile.

Brand marks: These might be a good indication of the diseases for which the camel has been treated in the past. Brand marks on a joint may show the camel has had joint problems or lameness. As a rule only owner's or tribal brand marks should be present.

Scars: Examine the animal well for scars and old wounds, especially on the short ribs and shoulders since these heal with difficulty and show that the camel has been used as a pack animal. A tuft of white hair on the hump or shoulder indicates a wound caused by use as a pack animal.

Females: If a breeding, pregnant or lactating female is being sold, it most probably has problems. Remember that a female may still be a heifer because it is sterile. All four quarters of the udder should be well developed, distinct and evenly spaced. The teat should be large. If the animal is lactating, milk it yourself or ask the owner to do it. Check whether she is pregnant (when approached by a bull or a man, if it lifts its tail, it is considered pregnant). Ask how many calves it has delivered, and check against the animal's age.

Males: The scrotum should be well developed and penis very long. The penis and testicles should not be injured or swollen. Ask to see any offspring the bull has sired.

Calves: Try to see the mother and father of the calves, if possible.

Q. Discuss the normal conformation of male/female camel.

A clearcut sexual dimorphism can generally be observed in camels. The male camel is usually taller and of heavier built than the female. The whiskers tend to be longer, the tushes more pronounced and in general there is a better overall muscle development. In geldings castrated before 3 years of age, the sexual dimorphism is less distinct. They attain full height but are of light built, the voice is more high pitched, the preputial sheath is reduced in size and dulaa (soft palate) cannot be inflated. The earlier the castration is done, the more pronounced are its effects on male camel. Conformation usually varies according to production type or the geographical habitat. Draught animal, milch type, meat and racing or riding camels are the usually recognized types in *Camelus dromedarius*.

Certain important conformation characteristics of the dromedary are: well developed prominent forequarters, being higher than the weak appearing hindquarters. Joint angulation is wider in the forequarters compared to the hindquarters, therefore front legs appear straighter and more in line. The elbows are clear of the body. A prominently

arched back is followed by a 15 to 20 degree horizontally inclined short loin. The rump is also quite short with an excessive downward inclination of 45 to 50 degrees from the horizontal plane resulting in a so called goose rump. Setting of the longer and wider feet in the front is square and even. Rear feet are slightly camped under and turned outward.

Q. Give below a detailed account of conformation faults that are commonly observed in one-humped camel.

Angular deformities of the skeleton, especially of the limbs, are one of the most commonly observed conformation faults in the camel. These are frequently seen in very young calves. Hyperflexion of the fetlock (caused by extreme contraction of the flexor tendons), undershot knees and lateral deviations of the carpal joints in newborn calves are often of temporary nature. These conditions resolve without treatment within 3 to 4 months of birth. Schematic presentations of correct and faulty positions of the pectoral limb in lateral view have been shown in Figure 3.

The normal position is the straight or post leg. Angular deformities of the fetlock cause some discomfort to the animal and predispose to lameness. Camped front limbs, either forward or behind, might be symptoms of acute painful conditions of the abdomen or chest or may be an indication of wounds of the foot, particularly injured sole. Figure 4 shows a schematic presentation of normal and faulty position of pelvic limb of the camel in lateral view. The straight leg and the leg camped behind both are considered normal, if however, the hind leg is camped forward, it is often an indication of an acute, painful inflammation in the abdomen.

Pigeon toes, splayed fetlock and brushing knees (Figures 5 and 6) are conformational faults of limbs commonly seen in large sized and heavy camels living in hilly areas. Malformation can predispose to other joint problems and lameness. Affected animals rarely show a good working performance. Camel pastoralists often try to treat these conditions by branding the affected joints. Occasional success is achieved in young still growing animals. In mature animals the condition cannot be corrected. The formation of a narrow chest in camel can be related to nutritional deficiencies during the early post-natal growth stages. This condition can predispose to other problems such as brushing elbows or brushing pedestal. Constant friction can lead to painful skin lesions and excessive scar tissue growth of the irritated area. Working ability can be severely impaired.

Q. What may be considered as a desirable udder conformation in camel? Also pinpoint important faults.

Just like in dairy cows and buffaloes, a desirable conformation of the udder is of great importance in camels. The camel's udder resembles closely to those of cow and buffalo. A desirable udder conformation in camels should include all characteristics, which are desirable in cows and buffaloes when milking by hand. The udder should be spongy, quarters well and evenly developed, the teats large, distinct and squarely placed. Spacing of teats is an important characteristic, since both milker and calf usually need access to the udder at the same time. Some of the common faults in udder conformation are: small udder, large but meaty udder, half of the udder deformed, teats small, teats fused at the

base with no clear distinction between two teat bodies and supernumerary teats. Insufficiently spaced teats become a predisposing source of infection from one quarter of the udder to the adjacent one. Small teats are difficult to milk.

Q. Write an essay on life span of the camel and camel mortality, indicating the stages of life when they are more prone to it.

Some authorities claim that the average life expectancy is 20 years. In Australia, a study of feral camels established a figure of 30 years. However, there are people who declare that camels live up to 50 years. This may be true in some individual cases, but the mean age is unlikely to be as much. The literature appears to support a range of 20 to 35 years, being representative of a large majority of the camel population. Depending upon the continuous work intensity, the camel's working life can reasonably be expected to be 12 to 20 years. The best years of an animal's life in heavy baggage and transport work appear to be from age 6 to 20 years. There are reports from the UAE of good camels winning races at 17 years age. Some authorities claim that breeding life of the camel concludes at age 20. This figure appears to hold good for most males, but the Australian feral camel study found females still breeding at age 30 years (Manefield and Tinson, 1997).

Apart from generally known causes of mortality such as starvation, malnutrition, fatal injuries and diseases, there is an age specific mortality in all species, which is high during post-natal and post-weaning stages. It falls to a minimum in the cohort of 4 to 12 year old, increasing again with higher age and reaching 100% at approximately 25 to 28 years. Whatever the causes of mortality, herd growth and productivity are adversely affected. The age specific mortality can be reduced by nutrient supply, better management practices and preventive measures against diseases. In particular, calf mortality is in most cases due to or related to malnutrition or starvation, even if actual mortality causes are diseases or parasitism. A whole range of interventions is conceivable which would have a good chance of significantly reducing early mortality. However, tolerating high male calf mortality in certain areas, can be a conscious management decision which is economically sound if the production target is milk and the demand for males for slaughter, work, breeding or racing is low.

Q. Does there exit any dominance hierarchy in camels?

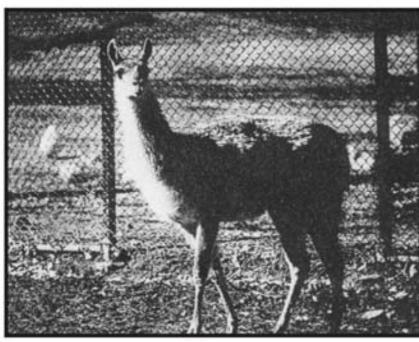
Because of their tendency to be rather widely scattered and their habit of moving relatively quickly from one feeding point to another, camels are more demanding of their herdsmen than are other domestic animals. This situation is perhaps exacerbated as camels do not form kinship groups and there is no stable leadership, although there is a dominance hierarchy in the order of adult males > females and bachelor males > subadults > calves, so the variable subunits add further to the herdsman's work load. Many camel-owning groups have thus adopted a tactic of riding one of the camels in the herd in order to better control the group as a whole. In Cholistan desert (Pakistan), large herds of free-ranging camels are seen and mostly they are not tended by any body except at milking time. Each herd has its own brand mark. Since Cholistan is mostly a state

owned large desert tract, grazing of camels, cows, sheep and goats is allowed in exchange of very nominal charges per animal/year. However, where land is owned by various tribes and big landlords, there tending of animals becomes necessary whether on foot or on camel back.

Note: Figures relevant to each chapter are given at its end.

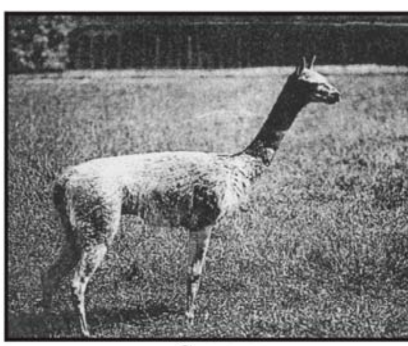
Plate I. Sources: Isani and Baloch (2000), Gahlot (2000).

Bactrian camel



Llama

Alpaca



Guanaco

Vicuna

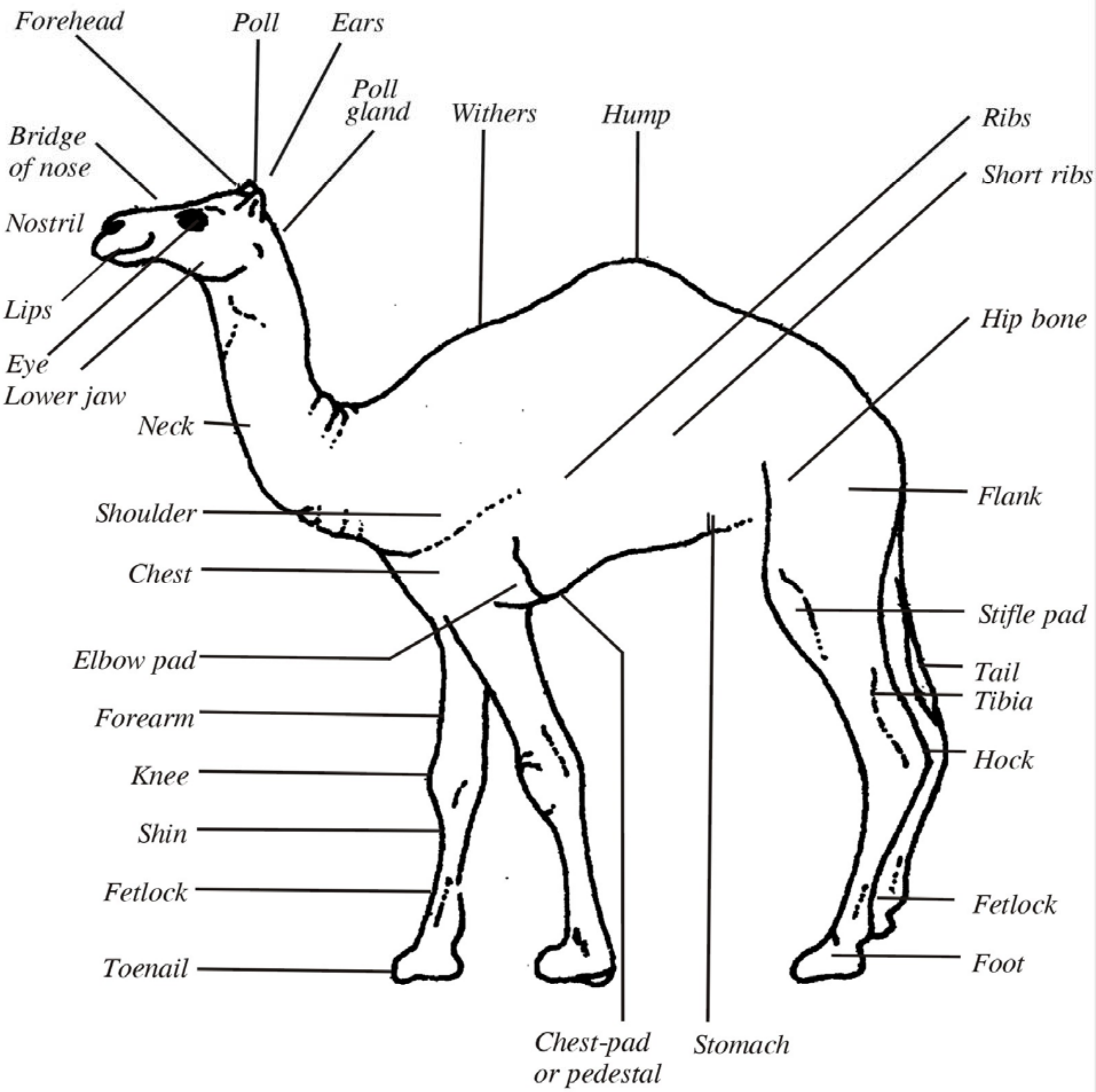


Fig. 1. Body points of camel
Source: K. Rollefson *et al*. (2001).

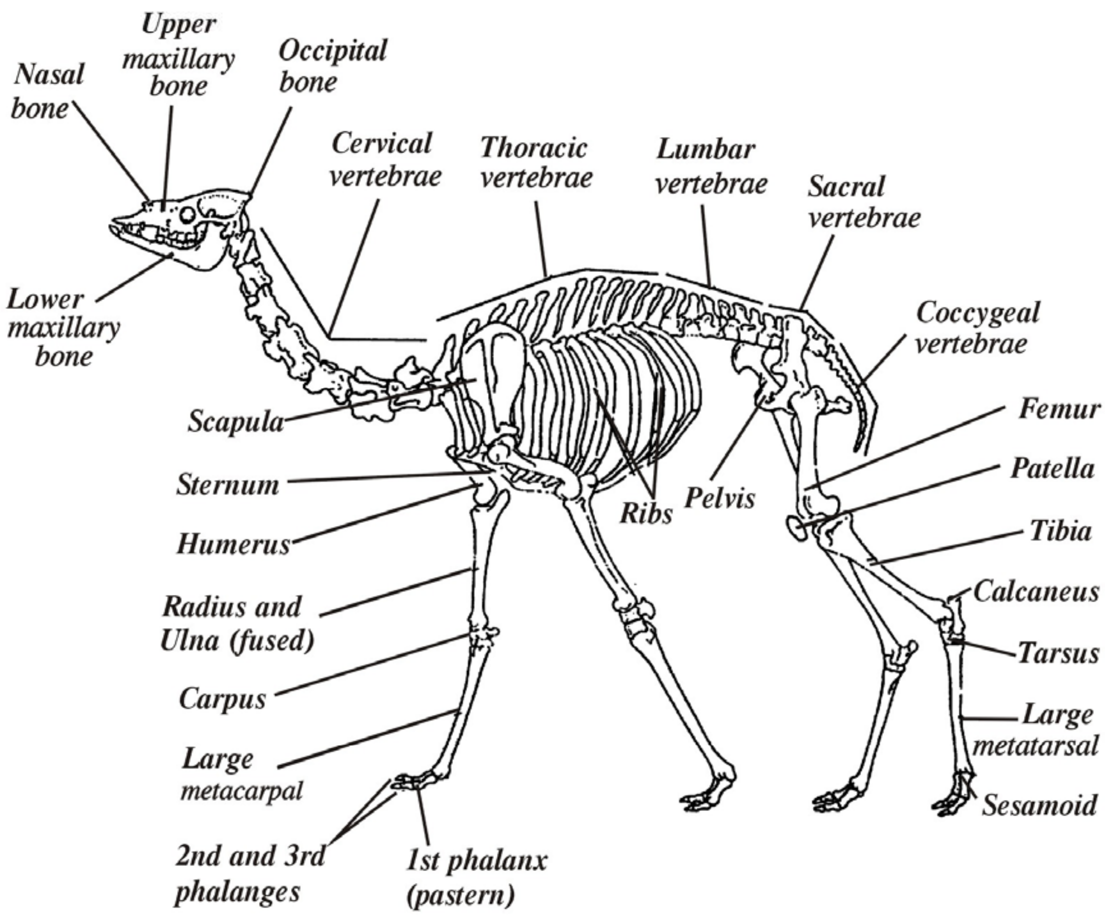


Fig. 2. Skeleton of camel
Source: K. Rollefson *et al*. (2001).

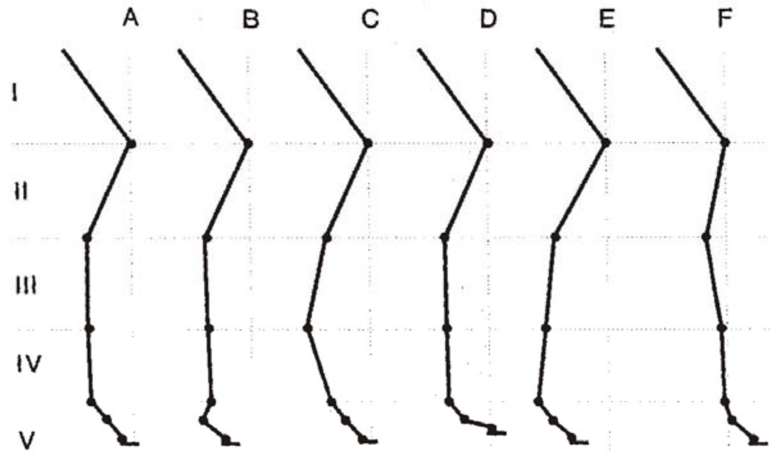


Fig. 3. Schematic presentation of normal and faulty position of the pectoral limb of camels in lateral view: A = normal (straight or post leg); B = contracted flexor tendons of fetlock; C = calf knee; D = hyperextension of fetlock; E = camped behind; F = camped forward; I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones
Source: Schwartz and Dioli (1992).

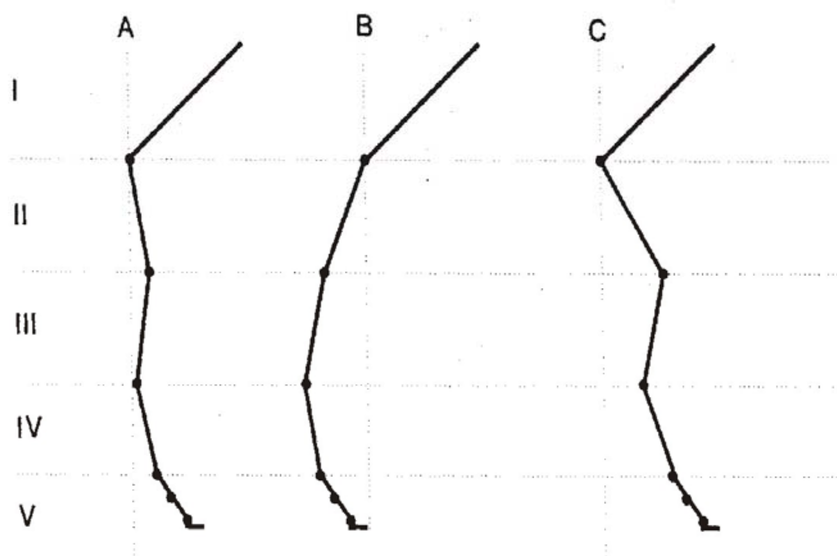


Fig. 4. Schematic presentation of normal and faulty position of the pelvic limb of camels in lateral view: A = normal (straight); B = camped behind; C = camped forward; I = pelvis; II = femur; III = tibia; IV = metatarsal bone; V = digital bones
Source: Schwartz and Dioli (1992).

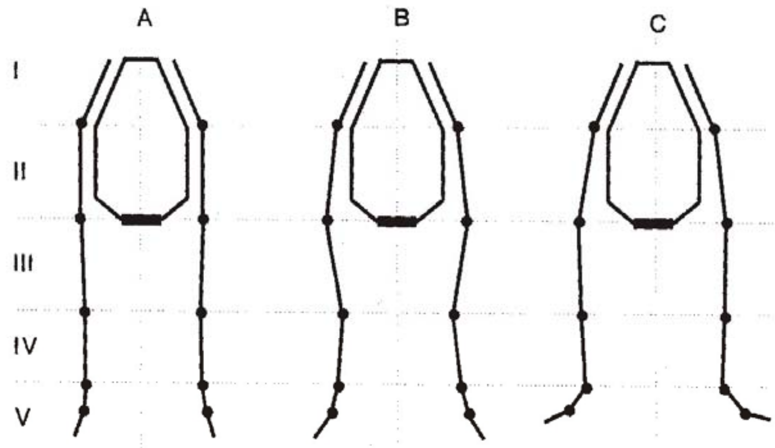


Fig. 5. Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: A = normal; B = carpal valgus (predisposition to C) C = angular deformity of the fetlock (splayed); I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones
Source: Schwartz and Dioli (1992).

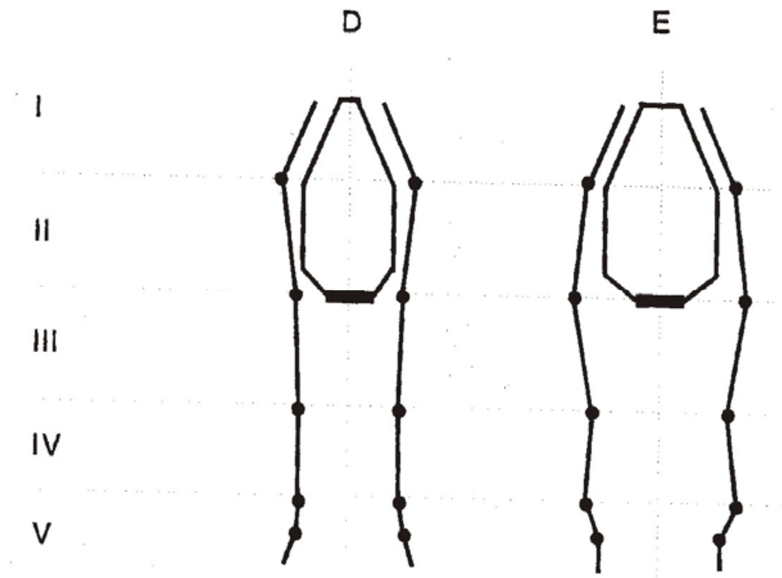


Fig. 6. Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: D = narrow chest (predisposition to brushing elbow and brushing pedestal; E = angular deformity of the fetlock (pigeon toes) I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones
Source: Schwartz and Dioli (1992).

BREEDS AND TYPES

Q. Discuss new trends in classification of camel breeds.

According to conventional categorization, camels are placed in four classes such as beef, dairy, dual purpose and racing. There appears little justification for such classification at present, because except in experimental lots, no camels are reared primarily as meat producers; racing camels do not constitute separate breeds, rather are selected from within existing populations only after they have shown a particular aptitude for speed and so on.

It was once said that no true breeds could be recognized and camels were named after the tribes that breed them and that types could often be identified with their help. Modern classifications have advanced little beyond these concepts, because little attempt has been made to assign the quantitative production parameters that are now so important in other species for the breed description. One such quantitative approach uses six morphological and biological characteristics such as habitat, function and geographical distribution, physical size based on linear measurements, ease of milking and rapidity of weight gain as parameters in the breed description. In Saudi Arabia, the most commonly used classification is based on colour. The relative proportion of colour varies from region to region depending on the selection process but it is not yet clear whether there are production differences between or among the colour types. In the former Soviet Union, all one-humped camels are of the Arvana breed. Three main types of Bactrian camels are also recognized in the former Soviet Union: Kalmyk, Kazakh and Mongolian.

Q. Do there exist precisely different specialized types of one-humped camels?

In most areas camels are multipurpose animals with the females used primarily as milk producers, the males for transport or draught and both sexes providing meat as a secondary or tertiary product. Capital accumulation and security functions are also of considerable importance for camel-owning groups. Largely as a result of the nomadic way of life there has been relatively little differentiation into specialized types in the camels. The lack of specialization can be attributed to the uniformly harsh conditions in which camels are bred and reared. Thus there owners require them to be multipurpose. However, a sort of specialization that has occurred is in the dichotomy of riding and pack types, both within the overall transport function.

Q. Do there exist pure breeds of camel? Discuss is detail.

Over the last so many centuries no organised efforts seem to have been made for planned breeding of camels to create pure breeds with specific purposes as do exist in buffaloes, cattle, goats, sheep and horses. No breed societies concerning camels exist. No doubt people interested in camels within their own regions, over long periods of time, selected for traits which make the camel most suited for work in that area. Some camel owning groups possessed extraordinary skill and they were able to fix the type. Such animals were then termed a ‘breed’, which in reality was not a breed. The development of a breed(s) is a slow and discouraging process, especially in camels, since the culling rate essentially required for rapid genetic progress is difficult to achieve in camel. The amount

of nutrients required for full expression of genetic potential may not be available. Necessary economic stimulus has been lacking. The camel has a relatively long (on average 5 years) generation time. Its reproduction rate is low. Neonatal mortality in many areas and situations is between 30 and 50%. A further constraint has been the necessity to integrate camel management with that of cattle, goats and sheep on the same range.

Selection for speed as is being practised by wealthy people with large herds in the UAE, Qatar and other camel racing countries is possibly the one contemporary exception to highly organized breeding. It has been demonstrated that, given sufficient financial support, it is possible to markedly reduce the constraints of low fertility and rearing difficulty in camels.

While it is arguably true that no pure breeds exist, camel types have evolved through time and expediency. In some areas the business of transportation has provided stimulus to select for superior performance in a certain terrain. Breeding has then proceeded within these groups on a ‘like begets like’ basis. Topography has a definite influence on type. Mountain and lowland types exist. Lowland types can be further divided into riverine and desert types. Riverine types are tall strong animals employed for draught and baggage work. Representatives can be seen in Punjab and Sindh areas of Pakistan and Nile delta. Baggage and riding types are represented among the desert camels. The real speedsters of the camel world are desert bred. The light coloured animals of the Sudan are especially valued for their speed.

Whether the present breed situation will change in time remains to be seen. Undoubtedly enough variation exists in mature body weight, conformational characteristics, working ability and production potential to make genetic improvement possible. The use of such technology as multiple ovulation, embryo transfer (MOET), can speed up the expression of genetic superiority. Improved husbandry practices and health cover can reduce calf mortality. Breeds suitable for specific purposes and regions could now be developed if the necessary economic stimulus is available.

Recent DNA studies suggest that the basis of breeds may already exist. What selection has been done, has quite likely established heritable genetic patterns. On the basis of colour this seems reasonable, with the pied camels of Mauritania, the pale camels of Sudan and some black strains in Saudi Arabia being examples. The Mauritanian camels have blue eyes.

Q. How many camel breeds are there in Pakistan? Give a provincewise list of such breeds.

Precise information about the camel breeds in Pakistan is not available. In fact the camel has so far not attracted the attention of planners and policy makers in this country. Its importance and potential as a milk and meat producing animal has neither been realised nor its role in agrarian economy has been properly assessed. Moreover, export potential of this species has also not been visualized. The camel appears to be a victim of intentional neglect as if it is an unwanted animal. Probably, none of the teaching institutions in Pakistan offering degrees in animal science ever included in their curriculum a teaching course on camel. However, very recently, the University of

Agriculture, Faisalabad, has taken lead and has included the camel in the teaching courses for the degree of B.Sc. (Hons.) Animal Husbandry.

In spite of an all out neglect, the camel as a farm animal and as an economic entity has not only survived but has also exhibited a steady growth in its population. This fact itself speaks of the importance of camel. A large number of Asian and African countries and Australia have shown growing interest in improvement and development of the dromedary. Investigations to effect improvement in various aspects of reproduction and production of the camel are underway in so many countries. In UAE, Qatar and other neighbouring states, development of racing and riding camels has assumed the proportion of an industry. In India, an independent camel breeding farm is functioning. In addition, a National Institute of Camel Research is operating there since long. The literature on various aspects of health and husbandry of camel is flooded with the names of Indian workers, whereas in Pakistan only a few studies on milk production, blood picture, some diseases and reproductive behaviour of the camel have been undertaken during the last decade or so.

Countries like Saudi Arabia and may be some others, are importing camels from Australia. We wish that our policy makers and the L. & D.D. Departments in various provinces of the country could do some serious thinking about the matter. Of course, camels in small numbers are exported from Pakistan too.

The only well documented information available about the camel breeds in Pakistan is by Isani and Baloch (2000). They have listed twenty breeds of camel in addition to some information about the Bactrian camel. The characteristics of some of the breeds are so much overlapping that it may be safely stated that there are more names than real breeds of the camel. In other words, except some very distinct breeds, the same type of animals found in contiguous regions of the country are claimed as different breeds, which in many cases, at best, may be termed as varying strains and not breeds. Isani and Baloch (2000) have rightly suggested that there are so many gaps in our knowledge in this regard, therefore further detailed studies might bring more facts to surface.

On the basis of information as mentioned above, the provincewise list of the camel breeds is as follows:

Balochistan: Brahvi, Kachhi, Kharani, Lassi, Makrani, Pishin and Rodbari

NWFP: Gaddi, Ghulmani, Khader and Maya

Punjab: Bagri (Booja), Brela (Thalocha), Campbelpuri, Kala-Chitta, and Marecha

Sindh: Dhatti, Kharai, Larri (Sindhi) and Sakrai

Q. Give salient characteristics and brief description of various camel breeds found in Pakistan.

reeds of Balochistan			**Weight (kg)**			**Milk yield (litres)**	**Lactation length (days)**	**Hair yield(kg)**	**General description**
a ne	**Habitat**	**Colour**	**Birth**	**Weaning**	**Adult**				
rahv	Desert area	Light to dark	48	98	692	1620	587	2.5	Baggage type, also used for ploughing, dense

	in Chagai district, distribution extends to northern area of Sindh	fawn, grey coloured camels also seen							long hair coat covering whole body in winter, comparatively short stature, wide chest, age at Ist breeding about 4 years, calving interval 719 days.
achh	Areas in and between Sibi and Jacobabad	Fawn	44	76	662	2018	516	2.8	Compact body, short neck, when in colder areas they grow dense hair coat, used for riding and as baggage animals, because of harder feet they work efficiently in mountainous areas, age at Ist breeding about four and a half years, calving interval 692 days.
hara	Kharan, Jhalawan and in areas bordering Kalat	Light yellowish to grey	42	71	624	1929	522	2.23	Small compact body, abundance of grey hair mixed with white hair on the body, equally popular for work in hilly and sandy areas, as riding animals they perform well in sandy areas of Kalat, age at Ist breeding about 4 years.

Breeds of Balochistan			**Weight (kg)**			**Milk yield (litres)**	**Lactation length (days)**	**Hair yield (kg)**	**General description**
Name	**Habitat**	**Colour**	**Birth**	**Weani**	**Adult**				
Lassi	Lasbella and adjoining areas of Balochistan and Sindh	Fawn with reddish tinge, dark red hair cover hump, shoulder and part of the belly	39	65	550	1305	300	1.25	Medium sized, muzzle pointed with a longer face, dual purpose animal used for riding and for carrying baggage, age at Ist breeding 3.7 years. Since hometract is Lasbella, hence the breed named as Lassi.
Makrani	Makran, Kharan, Lasbella, parts of Jhalawan and in some parts of Dadu & Karachi	The strain found in coastal areas of Karachi and Makran is light brown being darker over neck and flanks: The Jabilu strain is brown to dark brown, fawn coloured animals also seen	46	80	677	1929	519	2.6	The animals found in coastal areas are comparatively slim and smaller. The Jabilu type (mountainous) have long hair and comparatively stout built up, short neck, medium hump mostly soft footed; Jabilu variety has hair with black tinge on neck, flank region and legs above knees and hocks, Makrani camels are baggage type, if properly fed females are fairly good milk producers, age at Ist breeding on average is about 4 years.
Pishin	Pishin, Quetta and adjoining areas	Light brown to dark brown	49	98	702	1720	354	1.9	Pishin camels are baggage type and carry heavy loads, comparatively short statured, very sturdy, perform well both in hilly and sandy areas, cream coloured animals considered inferior, age at Ist breeding about 4 years.
Breeds of Balochistan			**Weight (kg)**						

Name	Habitat	Colour	Birth	Weaning	Adult				
Rodbari	Makran coastal range, Pasni, Turbat, area around Gwader, extending to Panjgur and part of Khuzdar	Dirty grey to light red	49	118	707	1693	467	3.0	Baggage type, comparatively slim body, short neck, part of neck that joins head and body including hump are covered with dense growth of hair, used for lifting water from deep wells, age at Ist breeding about 3 years.

ds of NWFP									
li	Lucky Marwat, part of Waziristan Agency and D.I. Khan	Creamy white	41	70	589	1310	315	2.0	Baggage type, also used for draught purposes, tall, well built, strong and massive legs with good stamina to work. It is considered by some a crossbred animal. Age at Ist breeding over 3 years, calving interval 736 days.
me	Habitat	Colour	Birth	Weaning	Adult	Milk yield (litres)	Lactation length (days)	Calving interval	General description
mani	Dera Ismail Khan, also found in D.G. Khan and Zhobe area	Mostly white coloured	50	125	738	2041	538	803	Tall, sturdy, baggage type camel, broad forehead, shallow depression in the middle of bridge of nose, lips large, lower part of the head and the adjoining lower part of the neck covered with dense hair, good stamina to work, also well adapted to work in forest area, hair yield 1.7 kg.

ds of NWFP			Weight (kg)			Milk yield (litres)	Lactation length (days)	Calving interval (days)	General description
me	Habitat	Colour	Birth	Weaning	Adult				
ler	Southern most part of NWFP, extending to areas between Sulaiman Range and Indus river	Creamy white	45	78	671	1656	450	789	It is a long legged slim breed, neck short, dorsal and ventral surfaces of the body run almost parallel and the body looks like a barrel, hump is small and placed right in the middle of nearly a straight back, primarily a baggage breed, hair yield 2 kg.
a	Tribal areas of NWFP	Dark brown to blackish	50	119	722	1519	480	807	Its general look is that of a Bactrian camel, neck short, well built and sturdy, dark brown long hair form mane as well as present on lower side of neck, throat, flanks and hump; long eye lashes and long hair in the ears, primarily a baggage camel, but also used for riding in rugged mountainous areas, hair yield 4.4 kg, because of its good speed it is locally named as

										'Maya'.

ds of Punjab			Weight (kg)			Milk yield (litres)	Lactation length (days)	Calving interval (days)	General description
ne	Habitat	Colour	Birth	Weaning	Adult				
bel-	Pothowar plateau including Attock, Chakwal, Rawalpindi Jehlum and parts of Sargodha and Mianwali	Fawn	54	129	741	1660	553	812	Primarily a draught breed, occasionally used for riding, mostly heavy weight animals, large head, short neck, dense growth of brown hair on throat, upper half of neck and hump, muscular legs, ears small, age at Ist breeding 3 years, hair yield about 3 kg.
- a	Pabbi, Kala-Chitta range, Sohawa and Salt Range	Mostly creamy, but animals with darker shades also seen	48	90	691	1496	310	820	A fine baggage type camel, adapted to work in rugged hilly areas, comparatively heavy breed, neck is massive with its three-fourth part covered with dark brown hair, ears a bit longer, hump well developed with a steep slope to the rump region, its home tract almost coincides with that of Dhanni cattle, age at Ist breeding about three and a half years, hair yield about 2 kg.

ds of Punjab			Weight (kg)			Milk yield (litres)	Lactation length (days)	Calving interval (days)	General description
ne	Habitat	Colour	Birth	Weaning	Adult				
echa ra)	Cholistan desert and adjoining irrigated areas, some specimens also seen in D.I. Khan and surrounding areas	Chestnut to blackish shades, other shades also seen	43	75	637	4180	429	748	Marecha camel serves dual purpose, riding and baggage, females are good milkers, they have medium head with a pointed muzzle, body in general not massive, legs long, hump well developed, neck comparatively long, age at Ist breeding is more than three and a half years, hair yield 2 to 2.5 kg.
i ja)	Cholistan and Thal deserts	Fawn is the favourite colour, brown and white shades also seen	44	75	656	2056	565	752	Good riding and racing animals, have lean body structure, mainly desert animals but when kept in irrigated areas they become heavy weight, their gait very smooth, without jerks, males trained for dancing and acrobatics fetch high prices, females good milkers, one strain of Bagries called Rojhan is found in Multan and D.G. Khan, age at first breeding is a little more

									than 4 years, hair yield 1.5 kg.

Breeds of Sindh									
Dhatti (Thari)	Dhatt area in Tharparkar, also found in Mirpurkhas, Umerkot, Sanghar and Badin	Light to dark fawn	40	65	570	2845	530	721	Excellent riding and racing camel, well adapted to travel fast on sandy soil, easily trained for dancing and to perform acrobatics; Dhatti a typical desert camel, has a slim body and long legs, head small and well carried, belly appears tucked up; belly, head and portion of the neck close to head covered with bushy hair; age at Ist breeding over 3 years, hair yield 2.5 kg, home tract Dhatt, hence breed named Dhatti.

ds of Sindh			Weight (kg)			Milk yield (litres)	Lactation length (days)	Calving interval (days)	General description
me	Habitat	Colour	Birth	Weaning	Adult				
ai	Kharo Chhan and Chohar Jamali, also found in coastal parts of Karachi, Thatta, Badin and parts of Kacch	Dark brown to black	43	70	602	1834	320	711	Kharaies are medium sized, neck and legs comparatively thinner, hump well developed, long black hair in ears, body surface is covered with curly brown or black hair, used mainly for riding and traction of load, they provide riding entertainment to visitors at Karachi beaches, age at Ist breeding three and a half years, hair yield over 3 kg.
ai	Mirpur Sakro to Sujawal Tallukas of Thatta district	Reddish brown, neck more darker	41	68	571	1480	312	720	Sakrai serve as baggage animals as well as for riding. They are not as good for riding, medium sized animals, short hair coat, hump comparatively well developed. They also provide riding entertainment at Karachi beaches, age at Ist breeding about three and a half years, hair yield 2 kg.

ds of Sindh			Weight (kg)			Milk yield (litres)	Lactation length (days)	Calving interval (days)	General description
me	Habitat	Colour	Birth	Weaning	Adult				
hi)	In and around Hyderabad and Badin, found on both banks of river	Dark fawn to dark brown	58	14 5	765	1818	512	704	Larries are riverine camels, good baggage and draught animals, heavy weight with massive body frame, head large with a prominent

	Indus, found in most parts of Sindh								cranium, broad chest, massive neck, hump well developed, legs strong, body coat short, tail broad with hair on sides and a tuft at the end; hump, upper half of the neck and shoulders covered with long hair, no good for riding, age at Ist breeding four and a half years, hair yield about 3 kg. Since they are found all over Sindh, therefore named Sindhi

ds of Punjab			**Weight (kg)**			**Milk yield (litres)**	**Lactation length (days)**	**Calving interval (days)**	**General description**
me	**Habitat**	**Colour**	**Birth**	**Weaning**	**Adult**				
a locha)	Parts of Jhang, Multan, Muzaffargarh, Mianwali including Thal area	Dark brown to light black	47	84	691	2841	478	754	Mainly found in riverine and irrigated tracts, big, tall and strong body with a massive head and neck, muscular legs, broad chest, well developed hump, somewhat hanging lips, good baggage animals, a section of people raises them as fighting animals and earn a lot of money, age at Ist breeding 3 years, hair yield about 2.5 kg.

Q. Give a detailed account of baggage or pack camels.

'Baggage' is the preferred term for camels since the word 'pack' is mostly used for horses and mules. The camels that carry goods on their back are called 'baggage camels'. They are usually heavier in structure than the riding type. Heavier muscling, particularly in the hindquarters, signifies a better ability to stand up with the load (Figure 7). Good general conformation is desirable. Baggage camels, as implied by their main function, have slower speed than the riding camels. In many situations it may be advantageous if the baggage camel can also be ridden, usually as a part of the total load. Therefore, the more comfortable, better going camels are preferably selected for this dual role. Larger feet may be desirable to spread the base of support and reduce the foot/ground pressure per unit area. Castrated animals are the first choice for commercial caravans. Animals of about 650 kg liveweight are considered ideal. Lighter animals must be loaded more lightly.

For almost continuous work, a load equal to one-third and not more than one-half of the camel's body weight is compatible with continuing good health and performance. With this load the camel comfortably can cover 30 km/day. The load is determined not only by the age, sex and stature of the animal, but also by the terrain to be traversed, the season, the availability of feed and water during the journey and its duration. Overloaded and/or overdriven camels lose body weight and become progressively weaker, despite being

well fed. A general rule to prepare a work schedule is that the camel should be allowed one day of rest for each day worked, but the rest period may be allowed after a work period of several days. Preferably, the rest be allowed in a favourable area. The working day should be restricted to about 8 hours. The camel being a ruminant needs ample time to eat and ruminate. A caravan incharge who knows the route will preplan his stops accordingly at favourable campsites.

Loading the camels should commence early morning and have them moving as early as visibility permits. In real hot climates, the march should stop at mid morning, the loads removed and, if possible, the camels allowed to browse. During this break the saddles may not be removed, but at least once daily the saddles should be removed and the camels examined for any problems, which might lead to abrasion or pressure necrosis of the skin. Overloading, overdriving and ill-fitting saddles adversely affect the animals making them ulcerated, thin with bony points more prominent at the end of a long journey. The march is restarted after mid afternoon. Where terrain and visibility permit, night travel may be favoured because it avoids the heat of the day and keeps the camels warm during the cooler hours. One man can without much difficulty control at least five camels, the total transported per man may be equal to that of a small truck. This means that in a country where the roads are poor to non-existent, the baggage camel may be the transport of choice.

Loading of the camel is best accomplished with the animal in sternal recumbency and, unless it is a fully trusted animal, the front legs tied in flexion by a rope over the neck or the halter held by an assistant. Packsaddle design varies a great deal in different regions. The loader should always make sure that the saddle is adequately padded to prevent skin abrasion, that the load is evenly distributed on each side and that the load is kept clear of the hump. When the camel is standing after loading, girths may be tight enough to just permit passage of the hand. No part of the load should restrict freedom of limb movement. Over tightening of the flank girth, either per se or as a result of load slippage, can damage the penis and urethra of male camels.

Conditioning of working camels–baggage, draught and riding–is important. Ideally, this means gradually increasing the load and distance traveled from half to full over a period of 8 to 10 weeks. This will benefit musculoskeletal system as well as the skin which will become tough at the load bearing points and more resistant to saddle sores. Fully loaded, unconditioned camels and those overloaded, are likely to have difficulty lifting the load and are subject to tearing of the muscular attachments of the forelimb. Long camel trips or continuous daily work should be planned on the basis of a loaded camel travelling 15 km/day (30 km travel and one rest day). They can be pushed a lot harder, but their body condition will not hold up, their resistance to disease will be diminished and their working life would be shortened. Well managed camels involved in baggage and transport work are expected to have normal working life from age 6 to age 20 years.

Q. Write a note on draught camels.

There are many countries in Africa and a few in Asia where even today the camel provides power for wheeled transport, tilling of agricultural land, grain grinding machines, for oil extraction devices, cane crushers and for drawing water from wells.

Castrated males of a heavy build are preferred but all types and even females are used. The camel is roughly comparable to the light draught horse in power output but staminawise the camel far exceeds the horse. The camel can be harnessed to two or four wheeled vehicles. Large teams were once used to pull wagon loads of wool in outback Australia. One example is that of a transporter in Australia who regularly hauled 14 tons of wool with a 14 camel team. Daily stages of 30 km with the loaded wagon and 45 km with the empty wagon were common for Australian team. May be the camels were changed along the way on long journeys and/or suitably rested at the end of each trip. It is a general rule that one day of rest should be provided to the camel for each day of heavy work, but not necessarily day by day. Perhaps work a week and then some days spelled. Otherwise the animals lose body condition and general health and resistance declines.

The draught camel drawing a wheeled vehicle has the advantage that it is not constantly supporting a heavy load against a gravitational pull. Once the load is rolling over the firm ground, the tractive effort is minimal on level going and almost nothing on a downgrade. Big effort is only required to start or make the load moving and on upgrades. In fact many camels are renowned for dead pull ability. They have been used to extricate stuck up motor vehicles.

For ploughing the camel can be used singly, in pairs and even yoked together with a different species. The stature and morphology of the camel requires a relatively high point of draught and, unless the traces are relatively long, there is tendency for the plough to lift. Possibly a camel of heavy build but short in legs should be selected for tillage work. Otherwise the distance of the camel in front of the ploughman may require the camel being led by another person. Six to eight hours of work per day is reasonable. Since ploughing usually is a seasonal work, therefore rest for the camel is not a problem. Off season provides ample time for rest and recuperation. One really good camel can plough 1 hectare of medium resistance land in 20 hours working 7 to 8 hours/day. In any form of draught work, particularly when ploughing, it is important that the harness is properly designed to suit the animal's morphology. Otherwise up to 50% of the animal's effort may be lost.

Q. What do you understand by the term 'downer camels'. Give the causes along with a suitable treatment.

Camels that are unable to rise to a standing position are called downer camels. There may be a variety of reasons for this problem such as damage to muscles, bones and nerves. Metabolic and some severe infectious diseases may also result into this type of inability. Severe pelvic fracture, hind leg long bone fracture, broken back, spinal injury and infections and abscesses, plant poisoning, snake bite, tick paralysis and epidural anaesthetic overdose all cause this inability. In addition, some camels conditioned by bad training learn that they can evade the handler's intentions by merely getting down and refusing to rise to standing position. It is, however, necessary to be sure that there is no other reason for the continued recumbency before using force to induce the camel to rise.

Pain and inflammation is often at least part of the reason for the camel's involuntary recumbency. Therefore, early use of antiinflammatory drugs e.g. Finadyne, Dexatomonol and corticosteroids (Dexone-5) can be of benefit. As soon as the primary cause of

recumbency is determined, its treatment must be pursued with vigour. A debate exists as to the value of using slings to get the camel off the ground, as against allowing it to be recumbent until it either recovers or is deemed to be a hopeless case. However, over the time it is necessary that these animals are assisted to stand at least twice in 24 hours and given support for some time to watch whether they have gained stability. It is important that these animals be fed a sound nourishing diet so that their strength may be maintained.

Q. Give a full length description of conformation of riding camels.

Riding camels should have a well-balanced conformation so that both the rider and the camel are comfortable at the faster gaits. They are finer boned and more agile than the heavier baggage and draught camels. The feet should be of medium size, but large enough to support the weight of the camel and rider and small enough to be consistent with agility. The forefeet should face forward while the hind may toe out slightly. The sole pads should be tough, yet pliable and evenly worn. The forelimbs should be well muscled, long and straight and, while closer together than in the heavier types of camels, the elbows must not brush the pedestal. The hind legs should be long, nearly straight to quite straight and free from sickle hocks and bowing. The croup should slope anteriorly up at 45-55 degree. The thigh and gluteal muscles, although small in camels and more so in riding camels, yet be well formed.

The head should be smallish, fine and neat, with large prominent eyes. The head carriage should be such that the anterior facial plane is almost parallel to the ground. The neck should show good muscling without coarseness. It should have a low body attachment and extend forward horizontally for almost half of its length before sweeping vertically upward. The body should show good chest capacity. The flanks should be short and the abdomen small but well rounded.

The description given above should not be interpreted to mean that animals lacking all the above features cannot be ridden. Any camel can be trained to be a riding camel. However, animals with less desirable conformation are usually less comfortable and tiring to both the rider and themselves, especially over long journeys.

Military protocol and records provide the best insight into the capabilities of the riding camel. The load includes rider, saddle, arms, and personal gear for army camels, which together make about 160 kg. The standard daily patrol for Egyptian Army camels was 40 to 50 km, Australian Camel Corps 55 km for 5 days and Indian Army camels 50 to 60 km/day. In Sudan, 60 km/day for 5 days and the same is for Rangers Camel Corps in Pakistan. For long and/or stressful journeys the camels must be conditioned first, commencing with some half distance, half speed work and should be gradually built up to the required performance over a period of several weaks.

The center of gravity of the camel is said to be about 15 cm above and behind the elbow. Therefore, for long journeys it is preferable for the rider's position to be in front of the hump. This position affords better control over the camel. For racing and the training of novice riders, a position behind the hump is preferred since it gives the rider a definite sense of security. In an emergency he can grasp the hair on the top or sides of the hump (Manefield and Tinson, 1997).

Q. Are riding and racing camels much different conformationwise? Give an outline of selection, training and management of racing camels.

Conformationwise racing camels are not much different from real riding type of camels. As a matter of fact racing camels emerge from fine and faster groups of riding camels. It is their training that helps them develop into racing camels. The fastest of them appear to have developed in Sudan, where racing as a sport also occurs since long. Camel racing has probably been going on since the animal was first employed for riding. As a highly organized sport on specially prepared tracks, with rules governing participation and conduct, it has only been going on for the last two and a half decades. Royal sheikhs and other wealthy people have set up breeding centers, some using sophisticated artificial breeding methods, to speed up the reproductive rate of their best camels and increase the likelihood of producing champions.

Although seemingly the camel does not appear to be a trainable animal, yet training must be undertaken to condition all the body systems to withstand the physical, physiological and psychological stresses involved. The intensity of competition dictates that every possible advantage must be exercised since races may be won or lost by a few centimetres. In the Arabian states, seasonal training commences in July/August with long training walk/jogs (gradually increasing to 20 km) in the early cooler hours of the morning. Practice conditioning races commencing at 2 and working up to 4 km are held regularly in September on country tracks. These tracks are generally straight raceways fenced with a top rail of water piping and a couple of plain wires. Gradually the camels are jogged and raced into fitness to race longer distances. In the UAE, racing on the main tracks commences sometime in October and runs through early April. In fact, there is some racing activity year round, while the already trained racing camels are resting from May to August, the new 2 year old crop is being trained and tested in the early hours of morning.

Segregation of competitor camels is made first on the basis of purebred local, crossbred Sudani and pure Sudani. They are further subdivided to run in age groups of 3 to 4 years, 4 to 5, 5 to 6 and over 6 years. The criterion for age is tooth eruption. Serious racing commences at the distance of 5 km. As the season progresses, most of the races are held over 8km. Tracks are so constructed as to provide the distance with one circuit. Over an 8 to 10 km distance the camels may get quite a long way away from the spectators. To compensate for this the grandstands are equipped with television sets. Race times do vary from track to track. For 5 km a very good time is under 8 min 30 sec, for 6 km under 10 min. For 8 km the best time is between 13 and 14 min, but camels running under 14 min 20 sec may win some races. For 10 km the best times are under 18 min, but 18 min 20 sec can still win some races. For a detailed account of training racing camels, you are referred to Manefield and Tinson (1997).

To be able to select superior racing camels at an early stage of their career, three scientific criteria are suggested. It has been demonstrated that camels that have exhibited superior racing performance have had larger maximum oxygen uptake capacity (VO_{2max}) than individuals with poor performance. It is an inherited trait and no training method seems to modify it. Better camels have a VO_{2max} close to 60 ml/kg/min, while poorer

performers may be in the 40 to 50 range. The same superior camels have also been shown to generate less plasma lactate when they are exercised at a given intensity (velocity and time) on a treadmill at a sub-maximal level. Tests for this trait would be best performed up to a 5% slope. Also, superior camels have a greater stride length, both pacing and galloping. This is also probably an inherited characteristic. A study showed that the fastest camels had the longest stride length and the lowest stride frequency. The fastest camel had a stride length of 5.6 m and a stride frequency of 1.64/sec at 32.5 km/hour. Such assessments can be made by using a treadmill. For VO_{2max} any workable system that can be used for the horse, should be adequate for the camel. The design and fitting of the mask is important, especially for the closed system where an airtight fit is required.

Management: For the purposes of management, racing camels are generally kept in camp groups of 25-50 animals almost throughout the year. Basic training of new young camels commences in special camps at about 12 months of age. After this they are tried as racing camels and only the swiftest find their way into a racing camp at about 2 years age. During the racing season, the camps are usually centralized near the race tracks, forming large communities of camps with thousands of racing camels. During the resting (hot) season, the camps generally disperse from the central location to some favoured area where the camels may be allowed free ranging during the day. These areas are also chosen for their relative freedom from worrying insects and disease occurrence. Each camp is self sufficient in having all necessary personnel, a water tank, a vehicle to transport fodder. Some groups may have access to a purpose built training swimming pool and a treadmill. Each camp is under the control of a head trainer whose assistants are responsible for timely feeding, exercise and continuous care of the animals.

Until a few years ago, all camels were tethered to a buried object within their camps, with front leg hobbled with a rope. This method is still used for many young camels. Now portable pens constructed from steel piping are becoming popular. They are so constructed as to pin together to form small pens or large yards. Some people do provide permanent stabling for their animals. They are usually runs of 4x4 meter pens under a gable roof. Height at the ridge is about 4 meters and at the eaves 3 meters. Most camps provide at least plywood or date frond (leaves) shade houses for the summer, often tethering the camels under them. This simple protection from radiant heat affords significant comfort. The desert nights and winds can be very chilly in winter. To protect the animals from wind chill, a common practice is to surround the camp with a permanent wall, a shade cloth fence, or bulldoze up a surrounding earth mound behind which the camel can couch and shelter. In addition the camels are rugged with a blanket. Nothing is worn for fast training runs (tafheems) on the track.

Feeding: Feeding and watering is performed daily. The camels eat and drink from flat troughs approximately 90 cm high, 2.5 meters long, 1 meter wide and 30 cm deep. Alfalfa and hay are often fed in similar troughs with fine mesh bottoms. Several camels may eat or drink from each trough simultaneously. Fresh water and feed are delivered daily by the camp's vehicles. Little actual grooming is done but the camels are washed almost daily with a motorized pump mounted on the back of the water tanker. Camels are

usually not watered within 48-72 hours prior to competing. This practice has not been found detrimental to their performance.

Fresh cut alfalfa is the main source of roughage in racing camel’s diet with occasional feeding of hay during times of shortage, while the main source of energy is barley. A typical daily ration contains 10 kg (fresh weight) of alfalfa tops, 3 to 4 kg of soaked whole barley, 1 kg of dates, 2 litres fresh milk, occasional hay and in some camps vitamin and mineral supplements. These quantities are divided between two feedings. The camels are reported to run well and look healthy on this diet, but there are reports of frequent digestive upsets. The quantity could be reduced if the grain was cracked. It would assist with maintenance of less acid rumen pH if more of the alfalfa stem and/or more hay is included in the ratio to increase the roughage and decrease the protein. Successful feeding of the racing camel requires that its ration must not be too bulky and gut filling to allow the camel to produce optimum performance and it should not be too highly energy concentrated and low in fibre to permit healthy rumen function. The feeding of vitamin and mineral supplements is becoming more common to seek some sort of specific performance boost rather than maximizing performance by optimizing general health through better nutritional practices. Much of the supplements fed are washed and excessive quantities may in fact be harmful. If some trainers have some success, they tend to think that if the recommended amount is good then more must be better. Camels in the UAE have been shown to be deficient in vitamin A precursors, vitamin B_1 and vitamin E.

The racing camel trainer likes his camels to present the silhouette (a profile or shadow-outline portrait) of a fit greyhound i.e. underline of the abdomen arched upwards. He feels, probably correctly, that a large belly impedes the forward action of the hind legs and reduces the power to weight ratio. A rumen reasonably full of fibre may be a healthy one, but it appears to be an unnecessary weight on race day. Management and feeding practices given above pertaining to the racing camels reflect those being followed in the UAE, probably the world’s premier camel racing country at the present time (Manefield and Tinson, 1997).

All camps are visited at least twice each week by a vet and daily when required. Some Sheikhs owning large camel herds employ their own vets and technicians and have sophisticated private laboratories. Routine blood and faecal samples are examined every 4 to 6 weeks. Additional samples are collected from sick camels for diagnostic purposes and whenever the camel registers a poor performance. Blood is drawn 48 hours after the race or fast track run to allow homeostasis to tend to normalize the measured values. The blood is collected into plain and EDTA evacuated tubes for biochemical and haematological screening. The blood is obtained before the camels eat or leave for morning exercise.

The trainer and his staff are very close to the camels and observe the smallest and most subtle changes in their behaviour. Certain parameters have been found useful in evaluating a camel’s fitness to compete (not necessarily to win).Although PCV cannot be used as a parameter to indicate fitness, it has been noted that camels generally perform best at values between 27 and 33%. The wise trainer and the technician attempt to

maintain the camels within these limits. Low PCV may be associated with environmental stress such as going to a new race venue or onset of disease or digestive upset. It appears to be seasonal with the coming of warmer weather. Severe parasitism and trypanosome infection are potent causes. Even if the parasites are not seen in a blood film, but if PCV is <25%, trypanosomiasis can be suspected. Mild cases caused by stress or idiopathic factors will often improve dramatically following the administration of haematinics and vitamins as tonics. To treat low PCV, Hemo-15, 10 ml and Jurocyl, 10 ml, both together in the same syringe IV daily for up to 7 days is useful or Folic/12, 10 to 20 ml IV daily for up to 5 days has given good results. It is advisable to give some vitamin B_1 as well.

High PCV may be due to temperament. Two year old camels, during their first year in camp, are particularly prone to it. The restraint must be gentle and the venipuncture and blood extraction done quickly and smoothly if a false high reading is not to be obtained. Some are even difficult to put the halter on and are upset and have a contracted spleen even before the technician approaches. Allowance for elevated PCV and erythrocyte count has to be made if the serum protein is within the normal range. The expected elevation is about 4%. True elevation of PCV seems to be associated with imbalance in water and electrolyte intake. The performance of most racers begins to deteriorate once the PCV reaches 35-36%. The serum protein may be at the upper normal to slightly increased level. For marked increases in serum protein occur in camel when it is severely dehydrated. Good response to treat for high PCV is usually obtained by the administration of electrolytes such as Lectade Plus or Hydrate Liquid twice daily for 3 days.

Serum iron levels fluctuate drastically in camel. Normal levels are between 50 to 150 µg/dl. Levels outside this range can indicate the onset of a serious disease and the camel needs to be carefully monitored. High iron level (>150µg/dl) with concurrent low PCV, has been reported in a group of camels with trypanosomiasis. Probably in these camels iron was being released from damaged red cells faster than it could be stored and/or excreted. Low iron level may be treated with injections such as Hemo-15 or Hippiron. High iron level can be due to underlying disease or overdosage. Excessive parenteral use of iron has caused kidney damage in equines. Serum copper levels are also regarded as important and optimum racing levels are between 50 and 100 µg/dl. Supplements used are Bomin, 20 ml, one dose or Copprite capsules 2 of 4 mg repeated after one month. Copper absorption or availability is complicated by the levels of molybdenum, sulphur and iron in the diet. Although camels are more tolerant of low and high levels of copper than sheep and goats, yet the intake needs to be monitored carefully because excessive intake is associated with poor performance.

Depressed appetite may be shown by camels after racing when overstrained, in illness, due to boredom with the diet or may be a chronic state of ruminal acidosis. It is important that the cause is identified. In conjunction with correction of the cause, Vigest can be used as an oral medication or Mega B, 20 ml, once daily can be injected as a tonic restorative. Camels that leave grain and only eat lucerne should be given some hay since they are probably acidotic. An oral dose of Ruminodigest and Bykagest antacid will help. When ruminal atony persists, Leocud powder, one, twice daily for three days will help.

Q. Write a note on milking camels.

The greatest collection of milking camels (over five million) is in Somalia and the adjoining areas of neighbouring countries. The milk of these camels is the main source of income and a key to the survival of the associated human population. Even here, where great use is made of the camel's ability to produce milk in very arid area, no selection has been made on the basis of measured milk production. Good milking camels do exist in Pakistan and some border areas of India but their potential to produce more milk has not been properly exploited. In North Eastern Africa where about two-thirds of world dromedary population is found, so great is the requirement for milk production and so low is the camel's reproductive rate that all females will be bred and milked. Culling of any animal with mammary gland seems impossible. Therefore it is not possible to apply the degree of selection pressure necessary to achieve increased production and type fixation.

No reliable work on results from selection seems to have been published. However, enough variation exists for selection to have significant benefit. Milk production for 305 days has been reported to vary from 1200 kg to 10,700 kg. It shows that given sufficient time for selection for milk yield, milk quality, less intense maternal instinct and development of management systems, camel dairying may be commercially feasible. It appears appropriate to suggest that if a milking type is to be developed, such activities will need to be carried out at appropriate institutions.

Q. Discuss the salient features of Bactrian camel.

The Bactrian camel (*Camelus bactrianus*) is two-humped. It is a sort of the closest cousin of the one-humped *Camelus dromedarius*. It is possible to interbreed the two species. The female progeny are normally fertile, long hump is a feature of the crossbred animals. Embryologically they are identical and may be subspecies of a single humped species. The breeding of F_1 hybrids probably commenced 2000 years ago and was a thriving business in Syria and Turkey seven to eight decades before present (BP). The favoured cross was a Bactrian male to a dromedary female, but the reciprocal cross is quite possible. F_1s were frequently backcrossed with a male of either parentage, but the Bactrian was preferred as the progeny resembled the male parent morphologically. Other crosses, especially the F_1 x F_1 were considered to produce weaker animal with an unpalatable temperament.

Bactrians from Bactria, an ancient name for the region of Western Asia between the Oxus river and the Hindu Kush mountains, is regarded as a part of the natural range of the Bactrian camel. It did not spread to the extent of the dromedary, and came to occupy a range running east-west adjacent to and sometimes overlapping the northern boundry of the dromedary range. This area includes mountains and the cooler deserts of China and Mongolia. The Bactrians prefer an habitat with an average ambient temperature <21°C, but the range of temperatures in these deserts can be very high between summer highs and winter lows. From ancient times the Bactrian has been raised to produce wool, meat and milk, and was first recognized as an important draught animal on the famous silk road. Today, they are primarily kept for wool production in China, Mongolia and southern parts of former Soviet Union. There are found different breeds/strains of

Bactrian camels in various parts of their range, reportedly developed for varying purposes such as superior wool or milk production or draught capability. Compared to the dromedary, the Bactrian is generally a poorer producer of milk (average two litres/day), but a better producer of wool. Its draught capability is about the same as that of a one-humped camel.

One of the most striking differences between the dromedary and the Bactrian is that of hump; the other pertains to the distribution and characteristics of coat. The Bactrian has a thicker, longer coat, a mane on the upper and under sides of the neck and an obvious tuft (like a forelock) on the forehead. The elbows and forearms are also covered with long hair. Their heads are relatively fine and their bodies are strong and robust. They are not as nimble (agile) as most of the dromedaries but the work rate at slower speeds is comparable. Their body colour varies from dark brown through fawns to grey with an occasional white, which is highly priced. They can endure hardship and within their own range can easily survive for 7 to 8 days without water.

For some time it was believed that the Bactrian camel no more exists in wild state. Recent investigations, however, have shown that wild Bactrians exist in a border area of China-Mongolia, in Lop Nur area, Aljin Mountain area and Taklamakan Desert. The number of such animals is very small (700-1000). Uncontrolled hunting and their capture for domestication adversely affected wild Bactrian population. Severe drought in 1980s further reduced their number. In contrast, the number of existing domesticated Bactrians is estimated as 2 million. To protect the remaining wild Bactrians, a joint project has been launched involving the Chinese Environment Protection Agency and the UNEA together with Mongolian and Russian input. The Lop Nur area having about 100 animals, has been proposed as the site for the International Protection Center for the wild camel and the Wild Camel Protection Society has been formed to prevent the extinction of the Bactrians as a wild species. The Bactrian camel was introduced to Ladakh area in the 19th century by traders from Tibet. With the closure of the trade route in 1950s, the animals were released in the grazing area of Nobra situated at an altitude of 3000 metres. They became a tourist attraction there. Because of their dwindling numbers a protection project is underway to preserve them.

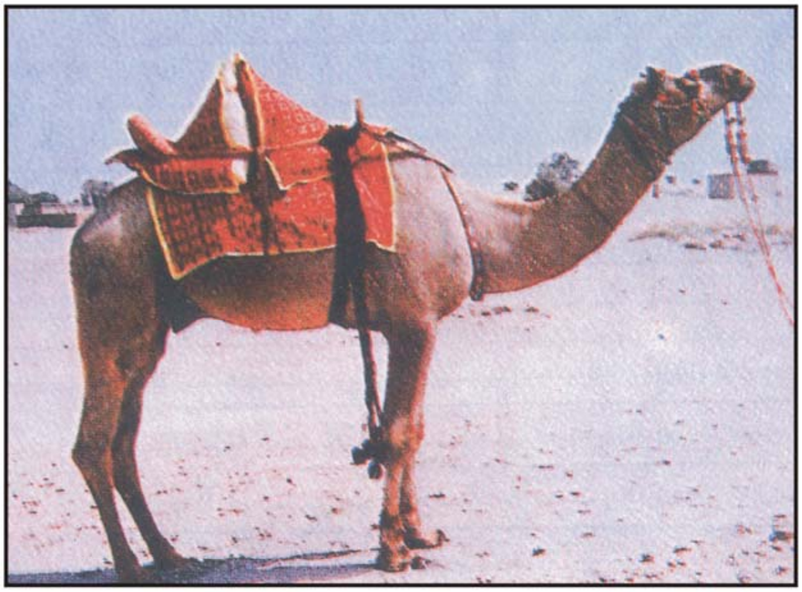


Plate IV Marecha camel

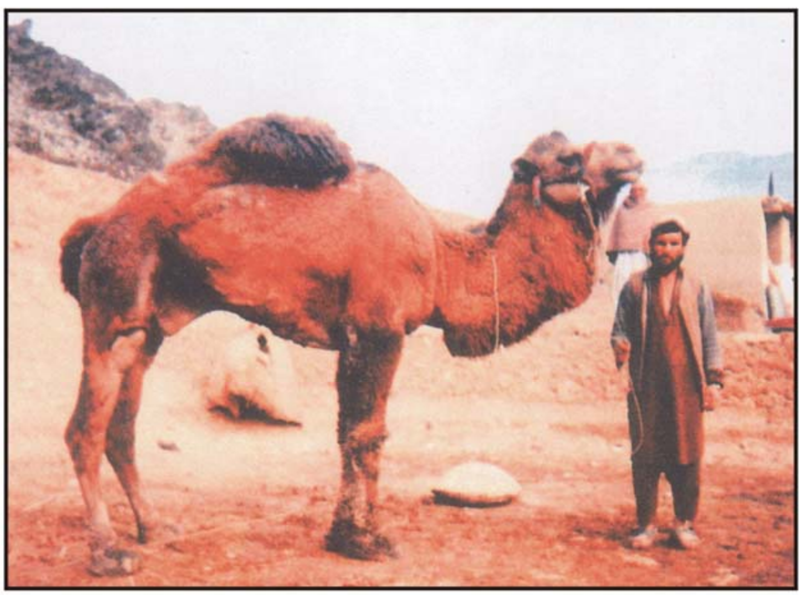


Plate V Maya camel

42 b

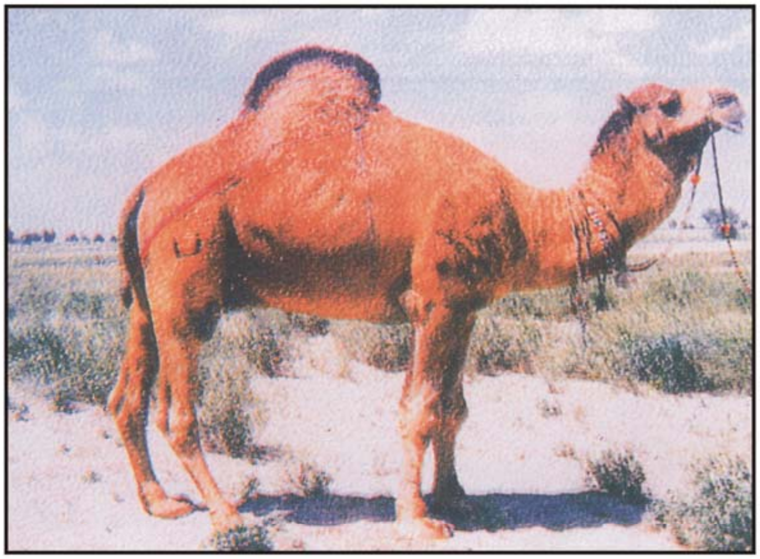


Plate II Larri camel

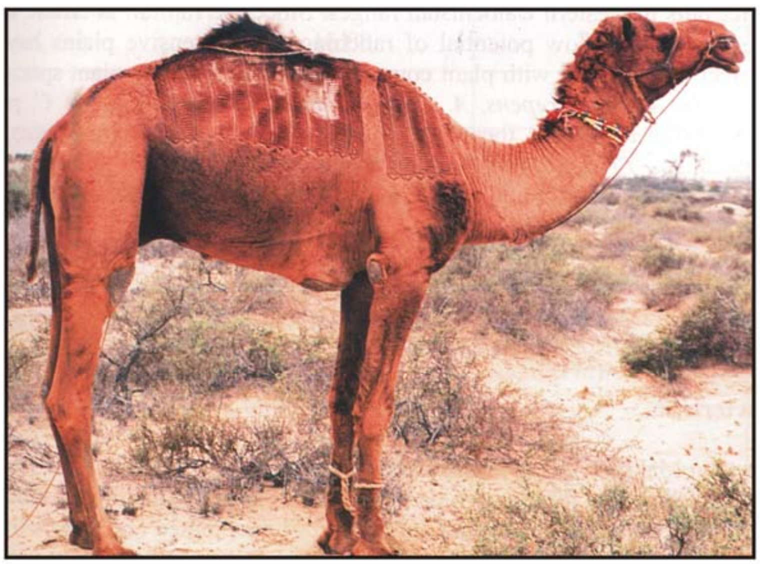


Plate III Lassi camel

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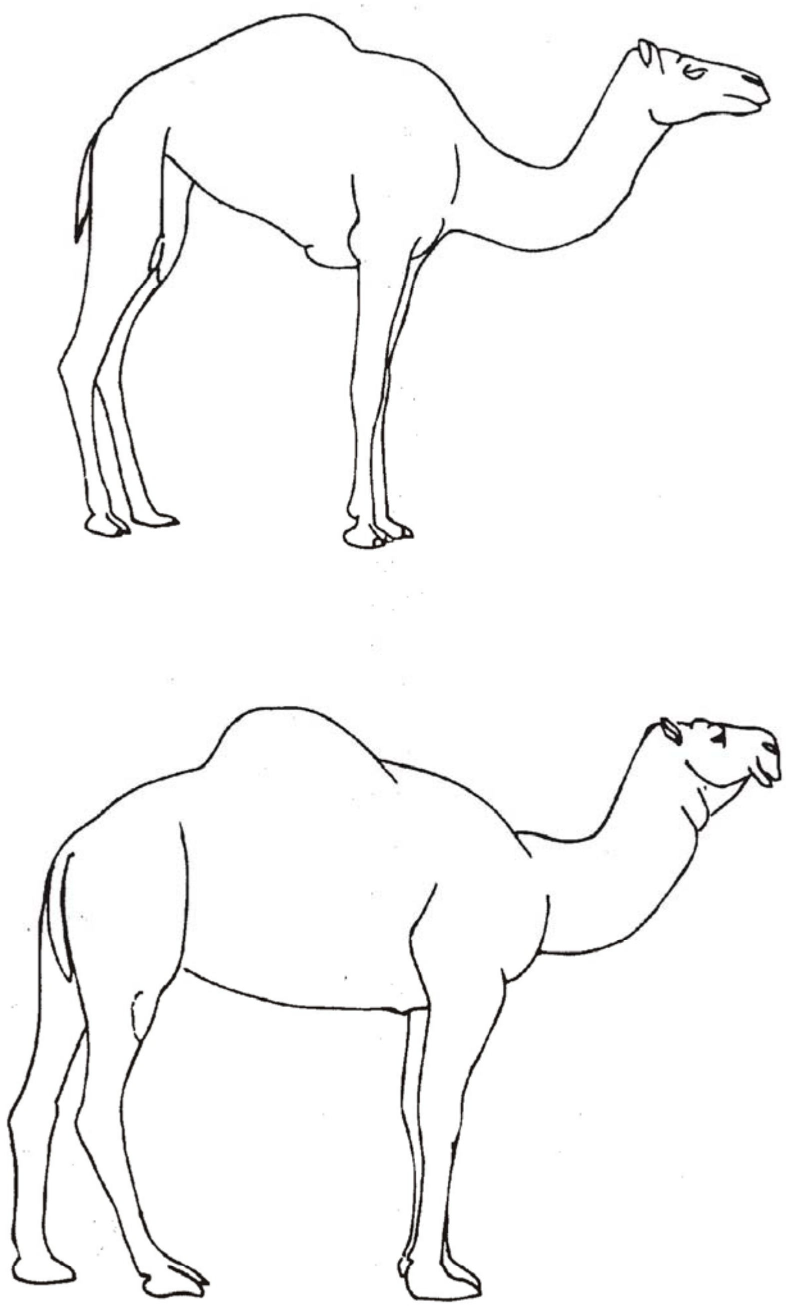

Fig. 7. Schematic presentation of the racing camel (above) and the heavy baggage camel (below)
Source: Schwartz and Dioli (1992).

FEEDING AND NUTRITION

Q. Describe some of the peculiar features of Camelidae in respect of their nutrition.

All Camelidae have a thin upper lip, split in the middle, and prehensile for selecting and grasping feed. The upper dental pad is hard. The small tongue is very active and helps in feed selection. All the salivary glands are very well developed and these allow digestion of the feed to start immediately when it enters the mouth. The oesophagus is very large.

The size and long legs of the camel, its economy in the use and turnover of water, its ability to stand high levels of salts in its feed and water and the peculiarities in its digestive system and digestive processes are adaptations to the arid environments in which the camel is usually found. The Camelidae seem to be much more efficient in digesting dry matter, fibre and crude protein than other ruminants and domestic non-ruminants. The way in which the stomach contents are turned over rapidly and frequently (although kept in stomach for a long time) is probably the reason for this better efficiency.

Q. Is camelid stomach different from true ruminant stomach?

The camelid stomach has three distinct compartments, whereas there are four in true ruminants. Although Camelidae are ruminating animals they are not classified as Ruminantia. They differ from true ruminants in that they walk on the pads of the two last digits instead of on the sole of the foot, they have no horns. The same general characteristics of rumination and microbial digestion of fibrous feeds in a large and compartmented stomach system have developed independently in camelids and ruminants. The independent development resulted in marked differences in morphology, histology and motility of stomach system.

The forestomach in camelids consists of three distinct compartments. The largest one is compartment 1(C1) which is subdivided by a strong muscular ridge into a cranial and a caudal portion. The relatively small compartment 2(C2) is only incompletely separated from compartment 1. The ventral parts of the compartments 1 and 2 are made up by series of glandular sacs. Compartment 3(C3) is a long tubiform, intestine-like organ, situated at the right side of compartment 1. The HCl producing hind stomach (H) is a short terminal part of the tubiform compartment 3 with no clear separation from it. The dorsal parts of the stomach compartments 1 and 2 are lined with smooth stratified epithelium. The ventral parts and the entire compartment are lined with glandular mucosa, which is arranged in longitudinal folds in compartment 3 (Figure 8). The most striking feature differentiating it from the appearance of the true ruminant stomach are the glandular sacs. These sacs were once considered to be the famous water store of the camel. It is now thought that the sacs are secretion areas for enzymes where fermentation of feed takes place. They are also the areas where the absorption of the digested feed into camel's system takes place (Schwartz and Dioli, 1992).

Q. Is intestinal system of camelids different from ruminants?

The intestines of camelids are similar to those of true ruminants. The colon is large in diameter and is a major site of water absorption. The liver is markedly lobulated. The camel has no gall bladder and thus does not produce bile to help in digestion.

Q. Write a note on rumination in dromedaries.

Initial reduction of the size of the feed eaten is achieved primarily by chewing, but this leaves fairly large pieces. Rumination or rechewing the cud is therefore essential for breaking down of particle size. The total time for chewing and ruminating is limited, restricting thus further breakdown of particles to very small sizes. Most rumination in camels that are herded by day takes place at night. Regurgitation of the feed from the stomach occurs at the time when the upper part of C1 is at its maximum contraction. Eructation (belching) of the gases that are the products of digestion and fermentation takes place at the same time as the contraction of the lower part of C1 and C2, while the upper is relaxed.

Q. Discuss recycling of urea in camels.

Camels are well adapted to diets that are low in protein due to their ability to recycle very effectively one of the end products of digestion i.e. urea. Recycled urea in reality is the same protein that is used more than once. The recycling rate of urea increases when camels are put under stress. Recycling efficiency of urea increases from 47 to 86% in camels in which dietary protein is reduced from 13.6 to 6.1%. The llama given diets containing the same level of energy but different levels of protein, those on low protein used 78% of nitrogen from recycled urea in metabolism, but animals fed a diet with high protein used only 10% of recycled urea nitrogen. Camels partially overcome the effects of diets that are low in protein by their ability to select high quality material. They can, however, only do this if they are given a wide choice of feed in grazing and browsing areas and allowed sufficient time to make their own selection. On the other hand, if they are provided with ordinary diets that are high in protein, they are simply competing with other ruminants and some of the advantages of keeping camels are thus lost.

Q. What do you know about stomach motility in one-humped camel? Discuss.

Stomach motility differs strongly between true ruminants and camels. In the former the total digesta in the reticulo-rumen are mixed and transported within the organ a few hours after feed intake rather homogeneously; in the latter particles and fluids are separated in a suction-pressure rhythm during the motility cycle, whereby fluids and solutes are pressed into glandular sacs for potential absorption, thus selectively retaining larger feed particles in the fore stomach for prolonged microbial degradation.

The contents of C1 and C2 pass to C3 when the strong contraction of C2 causes an expansion of the connecting canal. In llama, the flow rate is estimated at 850 ml/hour equivalent to about 17 ml at each contraction. The size of the digested feed particles varies from 0.1mm to 10.0mm in C1 and C2. The maximum size of particles which can pass from this area to the lower parts of the alimentary canal is 3 to 5mm in camels. The size of particles tends to increase as the amount of fibre in the diet increases. Digestion (to reduce the size of the particles) therefore takes longer if high roughage diets are fed.

Because the camel still feels ‘full’ it reduces the amount of feed eaten and therefore absorbs less nutrients for production purposes.

Q. The longer the diets high in fibre are retained in fermentation chamber of C1 and C2, the better it is. Discuss.

The time that feed particles remain in the fermentation chamber of C1 and C2 is important because it is responsible in large part for the amount of fibre digested. Longer retention times are required for efficient digestion of diets high in fibre. In the forestomach of the camel, small particles are retained for 41 hours, while larger particles are retained on an average for 57 hours. This is longer than in other camelids. For example, small particles are retained for 29 hours in the llama. Engelhardt (2003) reports that the bulk of fore-stomach contents is slowly turned around counter-clockwise within C1. Fluid is squeezed out of the bulk contents by the strong contractions. Due to the motility sequences, fluid and small particles are exchanged between the ventral region of the cranial and the caudal C1 and between the caudal C1 and C2. Fluid and small particles in C2 are finally sucked into the canal and are carried on into C3. Camels have longer retention times than true ruminants and therefore should be more efficient in digesting fibre although they perform better when allowed to select feed which is low in fibre such as green leaves of browse. Fluid is retained in the forestomach of the camel for 14 hours, this being shorter than that of the llama and true ruminants. High fluid turnover rates support rapid microbial fermentation through a higher buffering capacity and improve outflow of the soluble products of microbial metabolism. Major factors that seem to be responsible for large particles being retained in C1 and C2 longer than small particles (so that they can undergo further breakdown) are an unequal distribution of particles and camel motility. Large particles that do pass into C3 are held up to ten times longer than small particles and fluid in the omasum/abomasum area.

Q. Discuss in detail feeding behaviour and feed preferences of camel.

All livestock species (free ranging animals) ingest higher numbers of forage species during the growing season than during dry season. Goats (20 and over 25 forage species in growing and dry season respectively) followed by camels (18 and 22 forage species respectively) accept the highest number of forage species resulting in a more even utilization of available vegetation. Cattle and donkeys in comparison use a very limited range of forage species, which can lead to their overgrazing.

Cattle feed near ground level for over 80% of the feeding time, thus almost exclusively using the herblayer. Camels in contrast to cattle spend less than 5% of their feeding time near ground level and about 70% at heights of over 1.0m above ground. The preference of the camel for higher vegetation strata, gives the camel the advantage of continuous access to high quality plant material since all plants reaching this height are shrubs, bushes and trees, which are deep rooted, often tapping into the groundwater and remaining green long into the dry season or throughout the year, when the herblayer is dry and highly lignified. Plant species reaching the higher strata of the vegetation as a rule belong to the dicotyledon group. Since over 90% of their intake comes from dicotyledon plants, they can be referred to as browsers, whereas cattle, feeding almost exclusively in the herblayer and on grasses, are referred to as grazers. Sheep and goats, in

that order, rank as intermediate feeding types with a certain emphasis to one or the other extreme.

The one-humped camel when given the opportunity, selects a diet, which is higher in quality than the average of what is available, making the camel a ‘concentrate selector’. When allowed free choice, its preferred diet comprises mainly browse. A diet on browse consists on average of about 35% of leaves of leguminous and other trees and 65% of seeds, pods, flowers and twigs. Its ability to select high quality feed is helped by the long neck and legs and grasping upper lip and mobile tongue. Camel in this respect is rather like the giraffe.

Camels will not only eat tree fodder but also graze grasses if no or little other choice is available. In parts of Pakistan, India, in eastern Ethiopia, western Somalia, parts of Mauritania and in southern Arabian Peninsula, they are also grazers. In addition, the camels maintained by farmers in irrigated areas in Pakistan where crop agriculture is predominant, willingly eat green and dried guar and gram bhoosa.

Browsing is, however, of considerable advantage to the camel itself in reducing competition for feed resources with other species. The browsing habit is also advantageous for the camel owners in allowing them to keep a greater total biomass (more numbers) of domestic herbivores on a unit area, without contributing to increased environmental degradation and at the same time adding to the sustainability of the system.

When given a free choice, the feed preferences of the camel and its ability to select the most nutritious and digestible parts of plants ensure that it has a good quality diet that is high in protein throughout the year. It is able to maintain on a diet with a minimum crude protein content of 14% in the dry season, while cattle at this period are on a very low protein diet as reported from Kenya. In terms of cellulose content, camels select a diet with the lowest value of this feed component, while cattle have the diet with the highest proportion of cellulose (Table 3).

Table 3. Crude protein and cellulose contents (% of dry matter) at three seasons for domestic herbivore species in a part of Kenya

Livestock species	**Season and feed component (% of diet)**					
	Dry		**Intermediate**		**Green**	
	Crude protein	**Cellulose**	**Crude protein**	**Cellulose**	**Crude protein**	**Cellulose**
Cattle	4-5	37-40	6-8	33-39	10-12	32-36
Donkey	5-8	37-40	7-9	28-32	11-13	24-30
Sheep	9-11	20-29	10-13	17-20	15-20	21-25
Goat	11-14	15-22	11-14	16-18	17-22	16-22
Camel	14-17	14-22	14-17	13-16	18-22	14-17

Source: Wilson (1998).

Q. Does bite size or bite rate make some difference to browsing camels?

The selective habits of camels, while allowing feeding on very thorny species of browse, also make feeding a lengthy process. It is not only the rapidity with which bites are made which affect feed intake but also the bite size. A slow bite rate can be compensated for by large mouthfuls and if the dry matter content is high nutritional requirements might be fulfilled. On the other hand, a rapid rate will compensate for small bite size. In general, feeding habits vary widely, between different animals and even with the same animal. High rates of dry matter intake would allow a 300 kg camel to achieve a daily dry matter intake of 2.5 kg per 100kg liveweight (which is an average amount of intake for most ruminants) in a feeding period of about 6 hours. Slower rates of feeding could, however, mean long hours to feed (Table 4).

Table 4. Feed intake rates of camels in Mauritania

Feed type	**Bites (No./hour)**	**Bite weight (g)**	**Dry matter intake (g/hour)**
Acacia tortilis (branch tips)	140	1.00	140
Balanites aegyptiaca	260	2.00	520
Salsola	124	0.76	94
Nucularia	550	1.76	998
Maerua	440	1.26	528
Capparis	360	1.35	486
Ziziphus	500	1.10	550
Aristida pungens (dry stems)	240	2.85	684
Panicum turgidum (fresh growth)	760	1.65	1254

Source: Wilson (1998).

Q. Give estimates of dietary overlap between camel, cattle, sheep, goats and donkey.

Studies conducted in eastern Africa showed that camels compete least with cattle (i.e. they have least dietary overlap) for the same feed. A maximum of 8.5% of the same plant species is eaten by cattle during the green period and only 3.3% in the dry season of the year. The greatest competition for feed resources is found between camels and goats with 47.5% dietary overlap in the dry season and 12.4% in green season. Sheep (30.5 and 14.2%) and donkeys (18.9 and 7.2%) are intermediate in dietary competition with camels. Camels feeding in a national park in Sudan (which is normally not permitted) competed for the same feed resources with giraffe but there was little to no dietary overlap with antelope.

Q. Indicate relatively how much time in a day is spent feeding, travelling and resting by Arabian camels?

Where camels are herded, feeding and travel activities are usually limited to 12 to 15 hours that is daylight. Because they can go for long periods without water, they can thus make more effective use of time for feeding. In some areas camels spend more time

resting on watering days because of the long time they spend waiting at wells or other sources. In Kenya, camels spend up to 8 hours per day actively feeding and voluntarily travel 15-18 km in search of their nutritional needs. On watering days camels travel as much as 24 km. Relatively little time is spent resting by camels during the day while out at pasture. An indication of total time spent ruminating from Somalia is 6 to 7 hours, whereas a study in Pakistan showed average ruminating time as more than 7.5 hours. Nocturnal rumination time was about thrice as much as for diurnal rumination (Khan *et al*., 1996).

Q. Name the major plant groups used as feed by camels.

More than 70% and often as much as 95% of the feed selected by camels is composed of dicotyledons (broad-leaved plants including browse and legumes). Major plant groups eaten by camels include the Leguminoseae (*Acacia* species such as *tortilis*, *nilotica* and mellifera*; Indigofera*), burseraceae (*Commiphora*), Capparaceae (*Boscia*; *Maerua; Cadaba*), Rhamnaceae (*Ziziphus*), Simaroubaceae (*Balanites*) and Salvadoraceae (*Salvadora; Dobera*). Among the grasses, the *Aristida* species contribute to camel diets, as do *Stipa* and in very dry areas *Panicum turgidum*, is often a large proportion of total intake. As noted earlier, even when eating the same range as the other domestic herbivores, camels are rarely in direct competition with other browsers/grazers as they feed at different levels above the ground than do goats and sheep (Figure 9a).

Q. Write notes on intake and digestibility of feed in dromedaries.

Intake: There is still relatively little known about the amounts of feed eaten by camels, especially under free-ranging conditions. Published results are conflicting but it does appear that intakes of feed per unit of body weight are low compared to other domestic species. This may be because of the larger body size of camels and lower energy requirements but it again emphasizes the advantages of keeping camels, since they need less feed to produce the same amount of body weight as other species. Growing camels of one year age in Tunisia had a very low voluntary intake of 1.6 kg DM/100 kg liveweight with a gain of 326 to 525 g/day at a conversion ratio of 7.4 kg DM/kg of gain. Studies in Egypt have shown an intake of 4 kg DM/head/day (no liveweight figures provided) to give a gain of 214 to 238 g/day. Camels drinking salt water have lower dry matter, TDN and digestible crude protein intakes than camels consuming fresh water. Camels deprived of water can increase the proportion in the feed of TDN and digestible crude protein by selective feeding.

Digestibility: The proportion of the major nutritional components that are digested (the coefficient of digestibility) is often higher in camels than in other farm ruminants. This is because camels adapt to poor quality forage if they have no alternative sources of feed, in particular by increasing the retention time in the alimentary canal. The major strategy of camels in relation to diet quality, however, is to select green parts of plants with high protein and low cellulose. This strategy is aided by low energy use, high salivary flow and high levels of ammonium for microbial synthesis. It needs emphasis that camels should be allowed as wide a choice of feed sources as possible if best use is to be made of their ability to thrive in areas where other farm animals do not.

Q. Name the browsing and grazing plants found in Pakistan that are fed to camels.

In deserts of Pakistan, India, Iran, some of the Middle East countries and in parts of Africa, the plants, bushes, shrubs, weeds and trees are more or less identical. Before giving a list of browsing/grazing plants it seems appropriate to discuss that camel feeds can be divided into three groups. First group: green grasses, weeds, vines, twigs and leaves of trees, shrubs and bushes; second group: includes fodders that are dried and stored for feeding and almost all the feeds used in green state and straws of some of these left after threshing and third group: concentrates of all kinds i.e. grains, oil cakes, etc. A large number of plants included in first group grow in deserts, semi-deserts and plains of tropical and subtropical areas. Except a few poisonous plants, leaves of every weed, vine, shrub, bush and tree, whether salty or bitter-tasting, are eaten by camels. With the exception of a few vines, weeds and shrubs that grow in deserts, most of them have been classified botanically and their local names are known; the list of such plants is given below:

Shrubs, Bushes and Trees: *Solanum indicum* (oont kateri), *Crotalaria burhia*, Mangli, *Ameria modesta*, Wild olive, Pahari lana, Camel thorn, Zamai, *Leptadenia spartium* (khimp), *Aerua tomentosa* (bui), *Calligonum polygonoides* (phog), *Capparis aphylla* (kuril or ker), *Salvadora oleoides* (khar, van), *Salvadora persica* (pilu), *Ziziphus rotundifolia* (jharberi), *Ziziphus jujuba* (ber), *Prosopis spicigera* (khejri), *Prosopis juliflora* (pardesi khejri), *Acacia arabica* (babool), *Acacia jacquemontii* (bouli), *Acacia catechu* (khair), and *Acacia senegal* (kumta), *Albiza lebbeck* (siris) and *Azadirachta indica* (neem), *Sesbania sesban* (janter) *Prosopis cineraria* (jand), *Acacia modesta* (phulai), *Atriplex* (salt bush), *Haloxylon salicornicum* (lana), *Olea ferruginea* (kau), *Morus alba* (toot or mulberry), *Pennisetum purpureum* (Mott grass).

Vines: *Momordica dioica* (kakoda), *Tribulus terrestris* (gokhru, bhakra), *Citrullus colocynthis* (indrayan) and Sata.

Q. Do camels eat cultivated crops in green or straw form?

In addition to shrubs, bushes and green leaves of trees, camels in irrigated areas are fed on green crops such as moth, guar and jowar. Camels are also fed straws obtained from crops as bajra, jowar, makki, taramira etc. and bhoosa of gram, moth, mung, guar etc. Sometimes when a camel gets weak, green moth with grains or green guar with grains or if available lucerne and clover are also fed to help camel regain condition.

During drought years the leaves of the following trees may also be eaten by camels: *Ficus bengalensis* (banyan tree), *Ficus glomerata* (gular), *Ficus religiosa* (peepal), *Morus alba* (white mulberry), *Dalbergia sissoo* (shisham) and *Mangifera indica* (mango).

Q. How to feed dry roughages to camels?

Camels working in cities or those kept by rangers on desert area borders, under conditions of scarcity of grazing especially in summer, are fed dry roughages and some concentrates. Dry roughages consist of bhoosa (straw), tree leaves and pods collected in rainy season. When bhoosa of two leguminous crops as moth and gram or moth and mung is mixed, it is called missa bhoosa. Mixed bhoosa is commonly fed to rangers/army camels. Bhoosa (straw) is chaffed into small pieces. Chaffed grass mixed with straw of

one of two different crops is also used for feeding camels. Various types of bhoosa fed to camels, in order of preference are, moth bhoosa, gram bhoosa, mung (greengram) bhoosa and clusterbeam (guar) bhoosa (Table 5). When bhoosa is mixed with dried leaves of trees such as khejri or jharberi, it makes very palatable and nutritive ration for camels. Protein, mineral and vitamin A contents of these leaves are high. In hilly areas maize straw is commonly used for feeding camels. According to an estimate 8.3% camels obtain their feed (green or dry forage, straws) from irrigated/cultivable areas, while the rest mainly depend on range vegetation plus an occasional feeding of some molasses, concentrates.

Q. Do camels need concentrate feeding?

Free ranging camels probably are never fed concentrates. Common camel keepers most often do not feed concentrates to their camels unless they become rundown. In that case they feed some millet flour or barley flour and gur (molasses) for a few days till the camel regains his condition. Those who use their camels to pull camel-carts for haulage of goods or as baggage animals, they feed them concentrates daily to maintain them in good condition. Such concentrate ration usually consists of 0.5 to 1.0 kg moth flour or bajra or barley flour and 300 to 400g gur (molasses). In winter, mustard or sesame oil is given for 15 to 20 days to camels that are in poor body condition.

Table 5. Nutritive contents of some straws, bhoosa and grasses commonly fed to camels (% of dry matter)

Name	Moisture	Dry matter	Ash	Total organic matter	Protein	Ether extract	Carbo-hydrate
Bajra straw	5.07	94.93	8.00	92.00	6.00	1.00	85.00
Jowar straw	7.15	92.85	8.75	91.25	6.25	1.00	84.00
Moth bhoosa	5.15	95.00	15.00	85.00	4.25	2.00	78.75
Gram bhoosa	4.60	94.40	15.35	84.65	7.75	0.50	70.40
Guar bhoosa	-	-	16.51	-	12.90	0.87	57.40
Beri leaves	5.10	94.90	16.00	84.00	5.13	2.00	76.87
Khejri leaves	5.20	94.80	10.55	89.75	6.50	0.50	82.75
Acacia leaves	6.00	94.00	12.05	89.95	6.25	1.00	80.70
Phog twigs	4.50	95.50	20.75	79.25	4.50	1.50	73.25
Wheat	5.40	94.40	18.3	81.35	5.00	1.50	74.85

straw			5				
Siwan grass dried	5.60	94.40	10.75	89.25	4.75	0.50	84.00

Source: Rathore (1986).

Cereal or leguminous grains should be crushed and preferably soaked for about 6 to 8 hours before feeding. Oil cakes can be fed 0.5 to 1.0 kg/daily in combination with small quantities of other concentrates and gur (molasses). Cottonseed, if economical, may be given 0.5 to 1.0 kg daily crushed and soaked in water along with 450 g crushed moth, guar or gram. It has been reported to be a convention in certain desert areas in Indo-Pakistan to feed their camels about 1 kg molasses along with 25 g pink alum during long journeys. Both these components are mixed together in 3 to 4 litres water and poured down the throat of the camel. Molasses, of course, is a source of energy and perhaps alum is administered to counteract the laxative effect of molasses (Table 6).

Table 6. Nutritive contents of some concentrates commonly fed to camels (% of dry matter)

Name	**Moisture (%)**	**Dry matter**	**Ash**	**Total organic matter**	**Protein**	**Ether extract**	**Carbo-hydrate**
Gram	4.00	96.00	6.15	93.85	21.88	4.40	67.57
Moth	4.00	96.00	4.75	95.25	25.88	0.40	68.97
Guar	4.00	96.00	6.90	93.10	34.38	2.00	78.55
Moong	6.53	93.47	3.10	96.00	10.00	9.20	80.86
Bajra	5.67	94.13	4.00	96.00	10.00	9.20	80.86
Jowar	5.00	95.00	8.50	91.50	9.69	2.80	79.01
Wheat	4.00	96.00	4.75	95.25	11.88	1.00	83.37
Barley	5.00	95.90	7.75	92.25	10.35	4.20	77.02
Maize	4.10	95.90	7.50	92.50	10.68	5.80	76.02
Sesame cake	5.61	94.39	11.75	88.25	38.44	14.00	35.81
Mustard cake	5.77	94.23	6.15	93.85	28.75	11.00	54.10

Source: Rathore (1986).

Q. Give some examples of rations that are practically suitable for feeding of camels of various ages.

The army camel corps in India have prescribed rations for camels. These are regularly fed when the camels are stationed at headquarters. When they are on march or in camps, these rations are changed to suit the situation. When browsing/grazing is available the

roughage ration is reduced. With minor modifications, the rations given below can be applicable here as well.
When at headquarters, the suggested ration is:

Gram (crushed)	:	1.30 kg
Barley (crushed)	:	1.30 kg
Missa bhoosa	:	8 to 9 kg
Salt	:	0.14 kg

Camels are taken out for grazing, however, if grazing is inadequate, following ration is given:

Gram (crushed)	:	3 kg	OR	Millet with grazing	:	4 kg
Missa bhoosa	:	10 kg		Missa bhoosa	:	10 to 12kg
Salt	:	0.14 kg		Salt	:	0.14 kg
OR						
Moth crushed	:	3 to 4 kg	OR	Moth (crushed)	:	1.50 kg
Missa bhoosa	:	10 to 12 kg		Millet	:	1.50 kg
Salt	:	0.14 kg		Missa bhoosa	:	10 to 12 kg
				Salt	:	0.14 kg

Following rations have been prescribed for camels of various ages at the state camel breeding farm, Bikaner.

	Camels by age	**Fodder or bhoosa (kg)**	**Concentrates (kg)**	**Salt (g)**
a)	Under one year age	1.8	0.45	28
b)	1 to 2 years old	3.6	0.90	56
c)	2 to 3 years old	5.4	1.5	85
d)	Above 3 years	7.3	2.0	115
e)	Stud camels	8.2	2.5	142

Note: Ration scales a to d will remain effective from Ist April till 3Ist July when there is comparatively less browsing/grazing material available. From Ist August to 31st October, only half the above ration scales will be allowed if there are adequate rains and there is plenty of browsing/grazing available. From Ist November to 3Ist March, half of the above ration scale will be allowed if adequate browsing/grazing is available. This variation will not affect scale e above. In addition, stallions will be given 1 kg of mustard or sesame oil twice a week during the mating season i.e. usually from Ist December to the end of March.

Q. What is the daily salt requirement of an average sized camel?

Camels entirely on browsing/grazing do not need additional provision of salt. When they are working and being maintained on bhoosa or straw and concentrates, they need about 50 to 100 g salt/head daily. It may be mixed with flour or crushed grains. Camels appear

to have rather high mineral requirements. Occasionally they show preference for halophytic forage species, brackish water and salty soil. Standard mineral mixtures with an anthelmintic in proper concentration results in self-dosing against internal parasites.

Q. What are the proper times for feeding camels?

Free ranging camels are at liberty to browse or to take rest. Usually their feeding takes place during day time with one or two short intervals of rest and/or rumination. Large camel herds having owner's brand mark on them are not even tended by any body. It is a common practice in Cholistan desert in Pakistan as well. Individually owned camels whether used for intracity transportation or for farm operations, are fed in the morning before being put to work. In the afternoon when at rest, they are again fed and then in the evening. Those working in the city to pull intracity camel carts, they are often fed some bhoosa or green fodder whenever there is a loading or unloading interval. The cart drivers carry with them the feed for their camels. Ranger's/army camels are fed according to their prescribed schedules. They are fed early in the morning, usually about an hour before they are taken out for work or parade. In the afternoon they are fed again during the resting time; third time in the evening when camels are at rest. They are generally first fed concentrate ration and afterwards bhoosa is given to them for the night. When grazing is available, ranger's camels are sent for browsing/grazing in the day time; on their return in the evening they are fed concentrate, and as usual bhoosa is left before them.

Q. Give useful suggestions for proper feeding of one-humped camels.

i) Do not suddenly feed the camel with grains if he is not used to them.

ii) Do not starve the camel for long; this causes stoppage of cud chewing and the atony of the stomach.

iii) Do not feed grain or bhoosa after a long exhausting journey, especially if performed without feed and water. This may cause colic or impaction, and the camel may die. After exhaustion or fatigue, give the camel a small quantity of flour mixed with molasses and 1 to 2 litres of water and not more than 8 to 10 litres at a time, then after half an hour give him the usual feed [it seems to be, more or less, an empirical observation, however, a part of it does have some rationale].

iv) If offered the fodder of their choice, especially green fodder such as lucerne, green moth or jowar, the camel may resort to overeating, resulting into tympanites and flatulent colic. Therefore such fodders be given in modest quantities.

v) A camel must not be taken for long fast riding after heavy feeding, for he may develop colic or tympanites.

vi) The camel thrives best in the place where he has been brought up in his early life, for he develops a liking for the local shrubs, bushes and leaves. If, however, taken away from his native area, he should be fed carefully at first till he gets used to eating new plants; otherwise he may develop digestive upsets.

vii) The camels that are not fed at home would need at least 8 to 10 hours of grazing/browsing every day.

viii) Avoid sending camels for browsing/grazing in such area that has become slippery after rains.

ix) Camels should not be allowed to graze/browse in developing reserve forests, for they will eat away tender tops of young trees.

x) Do not feed the camel whole grains and seeds, especially barley, oats, gram, cotton etc. These should be fed after crushing and soaking in water for at least 6 hours. This will enable the camel to take full advantage of the grains or seeds.

xi) When the camel is not grazing, give him common salt every evening with concentrates.

Q. Write a note on supplementary feeding of camels.

Generally, camels are free-ranging animals and under many circumstances need little by way of supplementary feed. At certain stages of the life cycle, however, when camels are expected to perform extra work or produce more milk, additional feed may be required. With the exception of a few experiments, information on extra rations for camels is surprisingly scant. Suitable feeds for supplementary feeding are cereal straws, missa bhoosa, oilseed cakes, green or conserved fodders including grasses and legumes such as lucerne (*Medicago sativa*) or berseem (*Trifolium alexandrinum*), crushed barley, moth or guar and compound rations either home produced or ready manufactured. It needs to be stressed again that extra feeding should only be given for special purposes and to special groups of animals otherwise camel keeping will compete with that of other farm animals, which may benefit more from supplementary feeding.

Both energy and protein supplementation may be needed or just one or the other. For improved growth rates, for example, both are required. For work such as transport or ploughing, energy is the feed component most in demand, whereas more protein is needed for milk production.

Q. Does it seem possible to improve reproductive performance by supplementary feeding? Explain.

Better reproductive performance through improved nutrition can be achieved using two approaches: one to reduce age at first calving and the other to shorten the interval between successive births. Sexual maturity is often related to physical maturity, so if physical maturity is attained earlier, it would help attain puberty the earlier, whether female or male. For reproductive purposes, attaining earlier maturity in females than males is considered more important. Therefore provision of supplementary feeding to females may be beneficial. Feeding at any time will be helpful, but best results are obtained if animals are given supplementary feed from the time they are weaned.

In Tunisia, the camels receiving 500 g ready-mixed concentrate attained sexual maturity 6 months earlier than those given no concentrate. The youngest of the treated animals had its first calf at 3 years 2 months age and the average of all animals was 3 years 8 months compared with normal age of 4 to 5 years of animals receiving no supplementary feed. The supplementary feed group animals were also bigger and had better conformation. At the time of first conception these animals weighed about 64% of their final adult weight. Similarly, their height was more than 80% of the final adult height. It is desirable that

mating of camels for the first time should be at about these stages of growth. Camels with a high nutritional status return to heat more quickly than those in a poor condition. If it is intended to breed camels every 18 months, they should be provided with supplementary feed to bring them back into breeding condition quickly.

Q. Discuss feeding of camels for milk production.

Camels producing milk need large quantities of water (milk is about 90% water) and the main nutrient required is protein. A 400 kg camel producing 15 litres of milk daily requires 3 times the amount of protein of a 500 kg camel being used for transport but has only two-thirds of the energy requirement. Brassica crops, berseem and pods of several varieties of beans are said to yield good results. In general, any high protein type of feed given at about 250 g per litre of milk produced, should prove satisfactory for milk production.

Q. What type of feeds need to be given to working camels?

Large amounts of energy are used to perform work. Thus feeds high in carbohydrates or energy are needed for transport and draught camels. Energy is best supplied by cereals, their by-products, molasses etc. More expensive high protein feeds such as oil cakes should be avoided as they are better fed to other livestock for economic reasons (Table 7).

Q. Do the natural feed sources suffice to meet the mineral and vitamin needs of camels?

Camels on natural feed sources will normally take in enough minerals and vitamins for their needs. Where there are known deficiencies and no salt cure is possible, imbalances should be corrected by providing a mineral lick containing the necessary elements.

Table 7. Energy and protein feeds suitable for camels

Feed	**Type of nutrient supplied**		
	Energy	**Protein**	**Energy + Protein**
Standard concentrate mixture			***
Cereal straw	**		
Young green grass/legumes	**	***	
Grass hay	**	**	
Legume hay	**	***	
Oilseed cakes	*	****	
Wheat bran	**	**	
Cereal grains	***	**	
Pods of legume trees		***	
Leaves of legume trees		***	

Source: Wilson (1998).

Q. Write a note on voluntary feed intake of adult camels.

Based on observation of tethered animals, voluntary feed intake (VF1) of camels appears to be half to three quarters that of average sized buffalo/cattle, in terms of dry matter as a percentage of body weight. In practical terms it would be about 7.5 kg dry matter/day for a 450 kg camel. There are reports of adult camels having been maintained on 5kg of poor quality hay per day. VF1 in the camel is optimized when the roughage component of the diet is 70%.

Q. Discuss the energy requirements of the camel for maintenance and work.

A 450 kg camel's daily requirement of energy for maintenance on average are 37MJ. A camel performing draught work at a speed of 3.6 km/hour can sustain a pull of 0.15 to 0.2% of its body weight. This represents an output of 450 watts for a 500 kg camel. Assuming an energy conversion efficiency rate of 20%, 8.2 MJ per hour of this work would seem to be a reasonable allowance. It sounds logical to consider that baggage work would require almost equal inputs when the load they carry is given consideration. The requirement for faster work may be calculated from data generated from oxygen uptake studies. A figure of 2.0MJ/km traveled appears to be realistic.

Q. What advantage the camel has in respect of protein requirements over the true ruminants?

Due to its pronounced urea recycling ability, the camel is better equipped to handle protein deficient diets.

On a 4% crude protein diet, nitrogen balance in camels has been shown to be far superior to that of sheep. When subjected to water deprivation, nitrogen retention increased by 34% in sheep and 150% in camels. Even in watered state, recycling of urea to the rumen is very efficient in camels. In general, sheep consume twice as much nitrogen per unit of body mass as do camels. Fermentation rates in the forestomachs of camels appear to be similar to those of the true ruminants, but better nitrogen economy may be the basis of more efficient biosynthesis. There is some evidence that dietary crude protein levels for any class of camels such as pregnant, lactating, need not to exceed 9.6%. Its high urea recycling rate enables the camel to be a superior utiliser of low quality high roughage diets typical of the natural range plant material. Pending further evidence, it may be wise to provide higher protein levels for rapidly growing young camels and lactating females. For adult working animals, 300g of DCP should suffice. The requirement of racing animals and those under stress is similar but the quality (biological value) of the protein should be high. Camels also respond well to protected protein. The provision of 100g per day has significantly improved weight gains in camels in poor condition.

The requirements of camels for fat are not known. Probably they obtain all that is necessary from the feeds traditionally eaten by them. Racing camels are known to tolerate a daily intake of about 200 g of protected fat.

Q. Do camels have electrolyte requirements? Discuss briefly.

Electrolytes are important in camel feeding since the alimentary fluid is rich in sodium and bicarbonate particularly. Natural range plants are rich in these electrolytes. Artificial diets may induce deficiencies if not adequately supplemented. It is appropriate to include 2% NaCl in formulated diets for the camel. When crystalline salt is fed ad lib, an adult camel may consume 120 to 150 g/day. Hard salt blocks generally do not allow full intake

and may induce behavioural problems. Inadequate salt intake manifests itself in the form of skin disease (lackluster coat and necrotic dermatitis) and/or arthritic lameness and lowered production. In parts of North East Africa camels having salt deficiency are deliberately grazed on salty areas, which are known to effect ‘salt cure’

Q. Give a brief account of mineral and vitamin requirement of the camel.

The camel is said to tolerate deficiencies of minerals and vitamins better than other ruminants. Normally supplementation may not be required unless maximum performance is desired from the animals. Since many of the mineral and vitamin needs of the camel have not so far been quantified, therefore NRC standards for cattle may be followed.

With regard to Zn and Cu, the camel shows less effect than do other species in soil deficient areas. Daily intake equivalent of 18 to 20 mg of $ZnSO_4$ and 15 to 20 mg of $CuSO_4$ appears to be sufficient for good health. When drinking water and/or diet is high in sulphur and/or molybdenum, copper availability may be limited and intake be adjusted accordingly. Vitamin E and selenium deficiency can be a serious problem in camels in intensive breeding systems. Supplementation with vitamin E benefits both athletic and breeding performance. Daily allowance of 100 mg vitamin E and selenium 0.1 to 0.5 mg/kg of the diet appears to be adequate. A thiamine responsive condition regarded as being polioencephalomalacia is seen in racing camels. It is associated with imbalance of grain to roughage in the diet. Supplementation with dietary thiamine has been shown to raise blood thiamine levels. However, injections of thiamine may be a more practical and effective means of administration.

Q. Write a note on water requirements of one-humped camels.

Camel’s requirements for a source of free water depend much on type of grazing and environmental temperatures. Up to 20 litres per day may be met by herbaceous intake. During the cooler months camels may draw water from plants and standing water pools alone and may not seek to drink at a fixed water point for up to a month. Annuals and salt bushes contain up to 80% water almost in all seasons. Salt-containing vegetation has about the same water content in dry years as in wet. Camels show a liking for high salt herbage. Such plants are usually drought resistant. Their preference for high salt herbage explains high concentrations of electrolytes in the alimentary tract. Dune plants have a more stable year round water content than those growing on rocky ground.

Consensus indicates that camels drink once per week in summer, every 7 to 10 days in spring and autumn and every 3 to 4 weeks in winter. In 30 to 35°C air temperatures, visits to water points by free ranging camels will be sporadic. With temperatures >40°C, visits are likely to be regular at intervals of 4 to 7 days. Water requirement increases with activity. Given the same feed, yarded camels require less water than grazing camels that may voluntarily travel 30 to 60 km per day during browsing. In the Sahara, camels have marched 1000 km in 20 to 30 days without drinking water. Dehydrated camels will usually choose to remain stationary during the day, but can be forced to walk great distances. Racing camels are almost regularly deprived of water 3 days prior to competition in an attempt to improve power to weight ratio.

The power of kidney to produce urine with sodium concentration above that of sea water makes it theoretically possible for camels to quench their thirst from the sea. Certainly

they will drink brackish water but usually reject sea water. Visiting camels may sometimes refuse to drink brackish water that is being drunk daily by local camels. Of course, there seems to be a taste acquisition factor. Consideration of all the variables indicates that daily water allowance for camels should be 30 to 40 litres. Because of its lower urinary excretion rate (20% lower), and its much lower rate of faecal water loss, with water available *ad libitum*, the camel may consume only 10% of the water consumed by the bovine in the same environment (Manefield and Tinson, 1997).

Q. Do camels have a limited range of feedstuffs or is it otherwise? Discuss in detail.

Camels generally thrive in dry arid climates where feed quantity and quality vary widely, but most of the time quality is poor. However, the fattest camels, as indicated by their hump size, can be seen among those wandering the desert and not among the hand fed in domestic confinement. Nevertheless, there are times such as with a calf at foot, when the camel appears unable to satisfy its nutritional requirements by foraging alone. As with a good dairy buffalo, production of milk appears to have a higher priority than maintenance of body weight. The camel's digestive ability has been shown to be at least as efficient in utilizing low quality roughage as that of buffaloes. It can eat and digest a wide range of plant material. The camel does possess a microflora that facilitates digestion of a large range of plant material including tannins. These microorganisms do not normally inhabit the rumen of buffalo, cattle and sheep. However, the rumen of cattle and sheep sharing a range with camels will become populated with them and exhibit some enhancement of digestion. The camel's active forestomach contraction cycle and its active recycling of urea also enhance its digestive capabilities. The adaptability of the camel's digestive system has been shown by grazing them on alfalfa (lucerne) and panicum grass. Camels utilize these feedstuffs as efficiently as the true ruminants. Camels have been seen eating from garbage containers of Arab villages. Waste from fruit and vegetable processing can easily be supplemented with nitrogen rich saltbushes. Fattening for meat production has been profitable on a diet of straw, beet pulp, silage, molasses and barley.

The nutritional needs of camels kept in corrals and stalls have not been well worked out. Good health and fertility have been maintained on 5 kg of poor quality hay plus 2 kg of grain per day. While large (600 kg) working camels in Indo-Pakistan subcontinent are traditionally fed about 2 kg of grain, 9 to 12 kg (fresh weight) of green feed, 7 kg of hay/straw and some salt. Although precise requirements for camels in lactation are not known yet the allowances for buffalo/cattle would probably be a reasonable assumption. It is a common observation that free ranging camels with calves at foot lost body weight. Under these circumstances it does not seem possible for them to take in total required nutrients within the limits imposed by their voluntary feed intake (Manefield and Tinson, 1997).

Q. Write a note on feeding of racing camels.

Racing camels need a more concentrated diet. In order to obtain a better power to weight ratio, bulky feeds are restricted. Racing camel trainer feels very happy when his camel is in thin condition with the body underline being similar to that of a well conditioned

greyhound dog. Lack of roughage sometimes leads to the occurrence of thiamine deficiency. It is important that the protein fed to the racing camel should have high biological value. Since the bulk of the protein is rumen produced bacterial protein, the mineral status of the animal must be optimized. The imbalance due to excessive protein in the diet may result in inefficient utilization of energy and perhaps contributes to the indigestion syndrome so commonly reported.

Because of their high energy potential, fats could make a useful contribution to the racing camel diet. Fats probably only become an important energy substrate in endurance type races and seem to have little value in feeding for the usual 8 to 10 km events. The camel has been reported to tolerate dietary fat to the level of 3% of dry matter without compromising rumen function. About 200g protected fat has been fed to racing camels without any problem. The approximate daily feed intake of racing camels in the UAE, consists of up to 4 kg of soaked whole barley, 10 kg of fresh alfalfa tops, 1kg of dates, 2 litres fresh cow milk, occasional hay and in some camps mineral and vitamin supplements. The total quantity is divided equally and fed twice to the animal. Camels generally perform well and look healthy using this diet, but they do suffer from digestive upsets. These range from ruminal overload/indigestion to thiamine deficiency. These problems seem to be a legacy of the desire to feed energy dense diet with minimum rumen fill. The consequent imbalance between fibre and concentrates induces a chronic/acute ruminal acidosis, seriously affects healthy fermentation and bacterial synthesis of essential nutrients. One possible way to avoid this condition is to feed grain in a more digestible form such as cracked or flaked. Thus the required energy can be provided by less mass of grain. When whole grain is fed, undigested kernels have been shown to constitute up to 20% of faecal mass, that amount is totally wasted. This reduction in grain mass could then be substituted by good quality hay or the lower part of the alfalfa stalk. Usually the alfalfa is presented as sheaves and the lower half is cut off and discarded. Racing camels should be fully watered daily except immediately prior to fast work and racing. Some trainers have been reported to withhold water for up to 3 days prior to racing with no apparent harm.

Q. Does plant poisoning occur in camels? If it does occur, name a few such plants that may cause poisoning and indicate the usual symptoms.

Camels have been seen to eat known poisonous plants and suffer no ill effect. This is thought to be due to the very varied diet of the camel and its active ruminal contractions that thoroughly mix the contents. This tends to prevent the occurrence of strata within the rumen and building up of toxins to dangerous levels within these.

The handlers should be familiar with plants that are potentially poisonous. During long journeys they should not tether their camels at such points that are suspected of having poisonous plants. Camels moved into an area in tropical eastern Australia, consumed ironwood (*Erythrophloeum chlorostachys*) and exhibited staggering, star gazing, blindness and died. Hay contaminated with the bark of this tree was responsible for the death of five camels and illness in further 20. The toxins are alkaloid esters of diterpenoid acid. Ingestion of cape tulip (*Homeria breyniana*), oleander (*Nerium oleander*) in Indo-

Pakistan causes salivation, tremors, convulsions and death in camels. More investigations need to be done to determine what other plants have poisonous effects in camel in Pakistan.

Other plants known to be poisonous in Australia are: *Gastrolobium grandiflorum* (desert poison bush) with the toxin, a fluroacetate; *Gyrostemon ramulosus* (camel poison); *Dubosia hopwoodii* (emupoison bush) with the toxin, pyridine alkaloids; *Setaria* grass, toxin is oxalate content and *Trema tomentosa* (poison peach). In Africa, ingestion of the magico medicinal plant *Capparis tomentosa* has been reported to cause nervous signs including muscular tremors, stiffening of limbs, 'S' shaped distortion of the neck, dyspnoea and finally convulsions. Death often occurs in 24 hours. Post-mortem shows hydrothorax, hydropericardium and pulmonary oedema. Care and treatment of poisoned camels is almost the same as observed for large true ruminants.

Q. Name various other plants that can cause poisoning in camels. Give usual signs of plant poisoning along with appropriate treatment.

Some plants cause severe poisoning and death, while others cause mild disease such as stomach pain and/or diarrhoea. Poisoning due to different plants results in different symptoms. Camels usually recognize certain poisonous plants and avoid eating them. However, a camel may eat such plants when it is without feed for a long time or when it is moved into new grazing areas with no experience of the local vegetation.

Some of the following symptoms may result from poisoning due to different plants:

Excitement, depression, weakness, loss of coordination

Stumbling, jumping, running in circles

Groaning, kicking of the belly, bloat, stomach pain

Shivering, twitching in the face, head and neck, fits, convulsions, salivation or foaming at the mouth, difficulty in breathing, excessive sweating, uncontrolled urination, diarrhoea, vomiting, strange behaviour such as pressing the head against a post or a tree stump.

Stiffness, paralysis, coma and death

Prevention lies in avoiding grazing in areas known to have poisonous plants. Most of the treatments for poisoning are based on removing the poison from the body. These medicines are called purgatives, such as Epsom salt (magnesium sulphate, castor oil, mustard and linseed oils and liquid paraffin to make the animal excrete the poison in the faeces. Drenching with charcoal (½ kg ground charcoal) mixed with 3 to 4 litres of water helps prevent the absorption of more poison from stomach. Drench with 200 g kaolin (China clay) mixed with water. Repeat each day for 4 to 5 days (K. Rollefson *et al*., 2001).

Buxus semper virens (Phappar): It is an abdundant plant in Punjab (Pakistan) and Iran. It causes swelling of throat, cough, swollen belly, pain, vomiting and straining to defaecate, hard dry dung at first, then becoming soft, then evil-smelling diarrhoea, sometimes severe hiccough. The camel may die within 3 days.

The animal should be drenched with soup made from sheep fat. Mix 60 ml (about 12 teaspoons) of turpentine with 1 litre of linseed oil and drench. About an hour later, drench with warm ghee and milk. Inject 130 mg of arecoline subcut to make the animal

defaecate. Then give linseed tea or warm ghee and milk every 4 hours to soothe the inflamed gullet, stomach and intestines.

Calotropis procera (Aak): Camels do not usually eat this plant, but if they do they may vomit and have diarrohea.

Capparis tomentosa: It is found in many African countries and in some parts of Australia.

The camel's neck becomes twisted into an S-shape. The animal is weak in legs and staggers, convulses, death takes place in most cases within 24 hours after the symptoms appear. One of the treatments for poisoning listed above may be used. Better graze animals away from areas with many *Capparis* shrubs, especially along river banks.

Cassia occidentalis (*Senna, Kesudo*): It causes diarrhoea. The animal usually recovers unless a large amount of this plant has been eaten. Rice gruel given every 3 to 4 hours leads to recovery.

Daphne oleiodes (*Spurge laurel*, *Laghunay*): Treat in the same way.

Datura alba (*Thorn apple*, *dhatura*): A bush with large angular leaves, white funnel-shaped flowers and prickly fruit, usually found on banks of water courses. The affected camel becomes very quiet and goes to sleep.

Bloat also develops. Drench the camel with a purgative such as 0.5 to 1kg Epsom salt or one litre of castor oil/linseed oil/liquid paraffin and 2 to 4 kg ghee. Repeat the administration of ghee every 4 hours until the camel has recovered.

Euphorbia tirucalli (Milk-bush): It is a bush with small thorns but no leaves, growing in thickets beside water courses in some African countries. The milky sap is intensely irritating. The symptoms and treatment are the same as for *Buxus semper* virens.

Lantana indica (Lantana): This plant appears to be very poisonous to camels. Major symptoms are diarrhoea, sensitivity to light and rapid death. To eliminate the poisoning effects, drench three times with 250 g of ghee mixed with 250 g of jaggery.

Nerium oleander (Oleander, Nora, Kaneer): Normally camels do not eat it but those not familiar with this plant can eat and are affected. The camel stops feeding and starts vomiting 6 to 8 hours after eating the plant. There is dullness, shivering, yawning, staggering, diarrhoea, convulsions and the camel may die after about one day.

Immediately drench with 1 kg of Mag. sulphate. Also drench with 2 to 3 litres of linseed oil or a mixture of 4 litres of milk with 8 eggs. Inject 130 mg of arecoline subcut to make the animal defaecate. Only once a day, mix a little of tartaric acid in water and force the animal to drink it. About 5 minutes later, drench with 3 g of potassium permanganate dissolved in water. Inject 0.01 to 0.1g of atropine sulphate subcut. It relaxes the intestines.

Sacrotemma andongenese: Paralysis, twisting of the neck (as if it is broken) are the salient signs resulting from the ingestion of this plant. Preferred treatment is to drench the camel with baker's yeast mixed with sugar and water. Inject vitamin B complex. Also, give a drench of melted sheep fat.

Sorghum bicolour (Sorghum, Jowar): Sorghum stunted under drought conditions contains cyanide, a poisonous substance. When used in this condition, it causes poisoning

in many livestock species including the camel. It causes bloat and severe pain in the belly followed by difficult breathing and death.
Mix up to 25 g of ammonium carbonate with oil and water and drench. Drench with 500 to 1000 ml of Tympanyl or liquid paraffin. Inject 0.01 to 0.1g of atropine under the skin. As a last resort, puncture the rumen with a trocar and cannula or a sharp knife (Figure 9b).

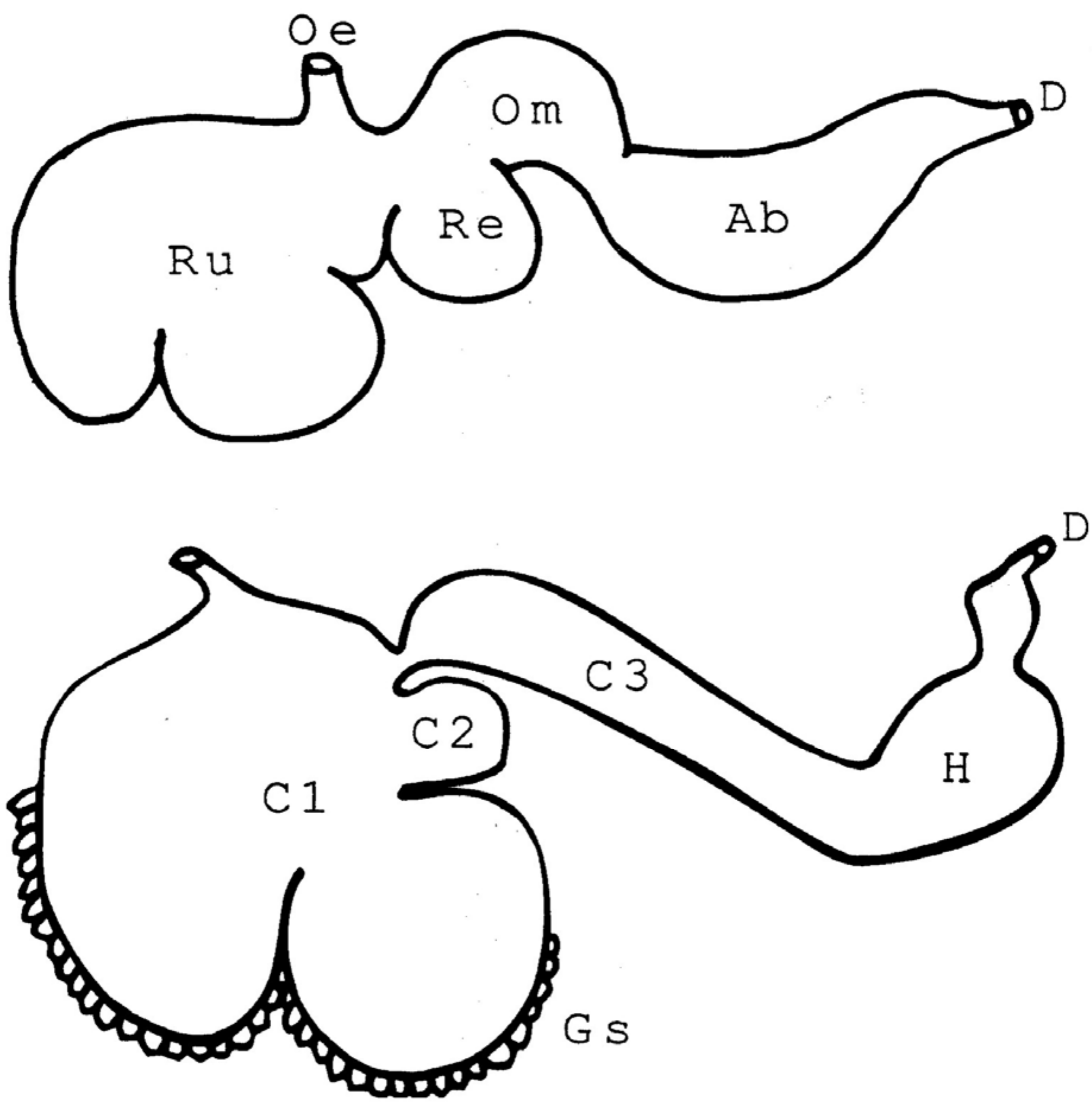

Fig. 8. Schematic presentation of the stomach system of ruminants (above) and camelids (below); Oe = oesophagus, Ru = rumen, Re = reticulum, Om = omasum, Ab = abomasums, D = duodenum; C1 = compartment 1, C2 = compartment 2, C3 = compartment 3, Gs = glandular sacs, H = hindstomach Source: Schwartz and Dioli (1992).

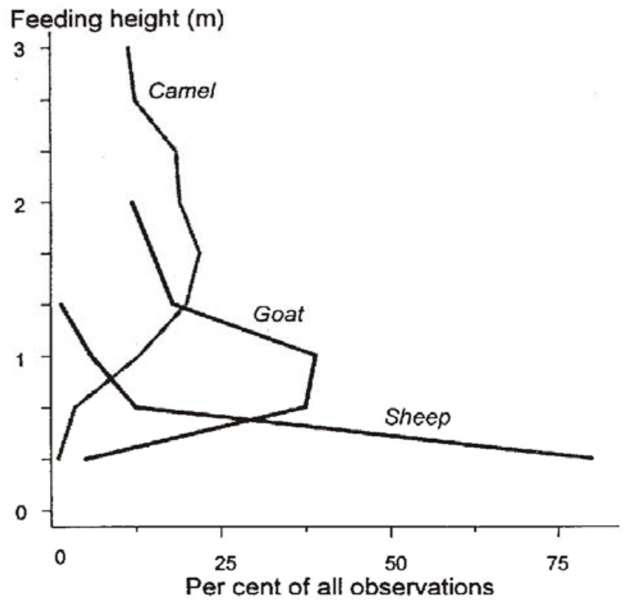

Fig. 9a. A comparison of times spent feeding at different heights by camels, goats and sheep in northern Kenya
Source: Wilson (1998).

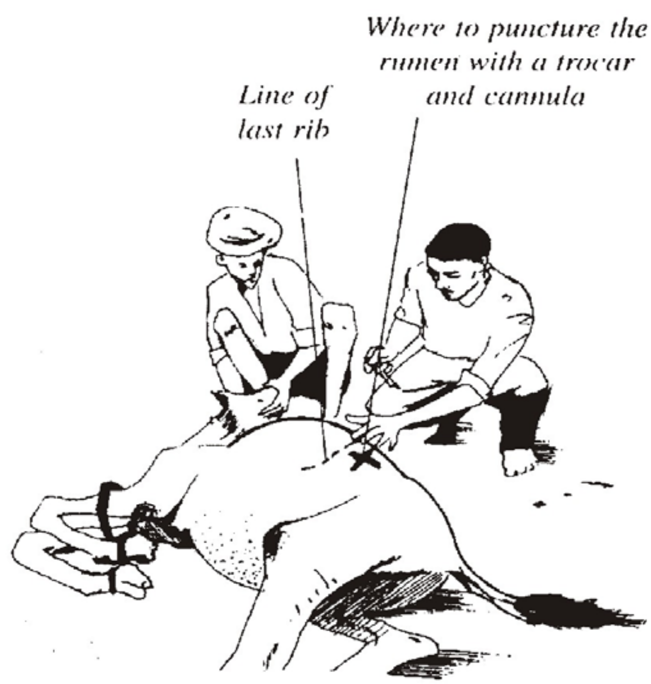

Fig. 9b. Where to puncture the rumen with trocar and cannula in case of severe tympanites
Source: K. Rollefson *et al.* (2001).

BREEDING AND REPRODUCTIVE MANAGEMENT

Q. Is hybridization between *C. dromedarius* and *C. bactrianus* possible? Discuss briefly.

For centuries it was believed that hybridization between *C. dromedarius* and *C. bactrianus* was not possible. However, this fallacy was disproved about 2200 years BP, but it was then assumed that the offspring of the interspecific mating were infertile as the mule and the hinny resulting from the donkey/horse. This latter premise has also long been proved false. It seems therefore that there is no reason, other than established usage, to maintain the species distinction.

Most research on crosses between the dromedary and the Bactrian varieties has been done in the former Soviet Union, especially in Kazakhstan. Hybrids have for long been known in Turkey, in northern Iran and in Afghanistan. Organized hybridization was still very important in Turkey in the second decade of the last century, when up to 8000 dromedary females were imported from Syria and farther south to be served by Bactrian males, being the most usual pattern of hybridization. The F_1 hybrids are almost always fertile with normal spermatogenesis in the male. The first generation female hybrid when bred back to one or other of the species produces offspring that resemble either of the male parent (dromedary or Bactrian). The F_1 shows heterosis in body size, hardiness, endurance and longevity. Some Bactrian characters such as hairy beard and legs are retained and the single hump is longer and not as well developed as in the dromedary. This cross is a strong draught animal whose wool yield tends towards that of the Bactrian. The milk yield and milk fat content of the hybrid are intermediate between the two parents. Other crosses, particularly from *inter se* breeding of the F_1, apparently produce weaker animals of poor conformation, which are difficult to train. Recently Dr. Skidmore (2002) in Dubai successfully crossed the dromedary with llama. The offspring was named as ‘Camella’.

Q. Give an overview of the camel’s reproductive performance, problems, and suggestions to improve the prevailing situation.

Camels are slow breeders with rather low reproductive rates. This in part is due to their large size, long life and their adaptation over thousands of years to the harsh environments in which they live. Reproductive performance can be improved by better management throughout the life of the animal, whether it be male or female. Good feeding practices in early life to encourage rapid growth and early sexual maturity will help reduce the age at which a camel has its first young. Possibly, early weaning of calves and improved nutrition of the breeding female during the period when the calf is suckling will help to shorten the interval between two successive births. Better feeding and management may also help prolong the lifespan of a camel. Diseases also affect reproductive performance. Trypanosomiasis, for example, reduces fertility and heavily infected animals may abort. Brucellosis and other bacterial diseases may also cause

abortions. Attention to health matters should thus be a priority. All these measures will result in more calves being born to a female during her lifetime and will thus reduce the need to keep large numbers of females. Overall management problems are thus reduced and damage to vegetation and the general environment minimized.

Q. Describe the anatomy and physiology of genital organs of a male camel.

Anatomy: The sheath or prepuce is large, fleshy, triangular in shape and laterally compressed. A well developed lateral preputial muscle along with the normal caudal and cranial muscles, directs the penis towards rear when urinating but toward the front at erection for copulation. The shape of the glans in the camel is like a crochet-needle (Figure 10), but it is straight and pointed in the buffalo or cow bull. Moreover, the sigmoid flexure in the camel penis is prescrotal, whereas in buffalo or cow bull it is postscrotal. At sexual maturity the penis becomes free of the prepuce under the action of the male hormone, testosterone; this usually occurs at about 3 years of age. The scrotum is small. It is attached high up between the back legs and does not hang loose. It is not distinctly divided into two compartments. The testes have already descended into the scrotum at birth but are small up to 3 years age. At this time a spectacular increase in weight and volume occurs as the camel reaches puberty. It is not advisable to use camels for breeding until they are at least four years old. Some viable sperm is present in camels throughout the year but male camels are the most fertile when their testicles are heaviest and largest. Tables 8a and 8b show the effect of age and seasons on testicular development in camels.

Table 8a. Testicular development in Israeli camels (age and testis position)

Parameter	**Age and testis position**					
	< 3 years		**3-5 years**		**≥ 6 years**	
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
Weight (g)	2.3	2.4	38.7	43.1	114.2	129.2
Circumference (mm)	38.7	38.7	94.8	112.7	145.2	154.6

Source: Wilson (1998).

Table 8b. Testicular development in Indian camels (season and testis position)

Age (years)	**Age and testis position**					
	August-November (moderate summer)		**December-March (winter)**		**April-July (extreme summer)**	
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
4-8	60.8	58.8	78.4	70.8	58.6	56.2
9-14	168.2	162.2	194.7	186.3	159.8	148.5
15-20	168.0	166.0	199.0	186.0	143.0	123.6

Source: Wilson (1998).

The seminiferous tubules are the site of sperm production. The seasonal changes that occur in tubule diameter are also related to fertility, these being widest when the testicles are heaviest and the camel most fertile. The epididymis (tube) carries the sperm from the seminiferous tubules to the testes to which it is attached to both ends. The sperm mature in the first and middle part of the epididymis and are stored for a time in its end part.

The erectile tissue of the penis comprises many venous spaces of various sizes, which contain elastic fibres but no muscular tissue. The end of the penis is curved in a sickle shape and there is no true glans penis. The penis is about 60 cm long. Its diameter varies from 2.2 cm at the root to 1.6 cm in the middle and to 0.4 cm at the extreme end.

Physiology: Under most conditions male camels attain puberty at 3 to 4 years. Spermatogenesis is continuous throughout the year, but in many areas activity varies with the season. Sperm production is at a low level at 3 to 4 years and rises to a peak at 6 to 7 years, varying on average from 70 to 370 m/ml. The possibilities of getting conceived of a female thus appear to be more with an older camel than with a younger one.

Male camels show a strong rut when they are ready for breeding. The intensity of the rut varies in different climatic areas. In Pakistan, the rut season usually is December to March. However, February, March and April are the usual months for breeding in the highlands. The physiological changes associated with the physical signs of rut are an increase in androgens in the blood. The poll glands in male camels increase in size during the rut and secrete a sticky dark reddish fluid which has androgen concentration similar to that of the blood. These secretions are often the first signs of the approaching mating season and an indication for the handler to prepare his herd for mating.

Q. Write a note on the accessory sex glands in the camel.

The prostate gland in the camel is a discoidal mass, dark yellow in colour and located on the superior edge of the first portion of the pelvic urethra, at the level of the neck of the bladder. It measures 3.7 X 5 cm. It has several ducts on either side, which perforate the urethra. The bulbo-urethral glands are formed by two lobules situated on either side of the terminal portion of the pelvic urethra. They are whitish in colour, almond shaped, and measure 2.5 X 1.2 cm. The seminal vesicle is not present in the camel.

Q. Discuss the behavioural changes that are usually observed in a camel in rut.

A rutting bull when approached by other males or humans, assumes a typical stance. The rear legs are widespread and the bull positions himself laterally so that he seems bigger and more threatening. He shows typical scent marking behaviour. The poll gland secretion is rubbed onto shrubs repeatedly, especially in the presence of other bulls. In bachelor herds mostly bulls appear to go through a quiescent rutting period, which develops into full rut when a male joins a female herd. During the rutting period, the camel becomes aggressive to other camels, to its handler and can be extremely dangerous. A rutting male grinds his teeth, lashes his tail, waves his head and neck, froths at the mouth and urinates frequently, splashing urine all around. During rutting the incidence of fights among males in mixed herds is very high. After having established dominance, only the dominant bull, which is usually the oldest and heaviest will display the characteristic behaviour, while other males only show a subdued version or lose libido and go out of rut. The dominant bull drastically loses condition due to loss of

appetite and reduction in feed intake; at times diarrhoea may accompany. His abdomen is markedly tucked up and hump gradually decreases in size. A characteristic feature of the rut is the protrusion of the soft palate or ‘dulaa’. The palate is filled with air from the lungs and it is possible that its protrusion and the accompanying gurgling sounds are attractive to the female. Rut is a period of strong sexual activity during a limited time presumably controlled by the level of testosterone. Rut can be induced with gonadotropin treatment and better nutrition.

Q. What do you understand by the term ‘Dulaa’?

Dulaa is the Arabic name for the mucous membrane covered expandable diverticulum on the ventral center of the Arabian camel’s soft palate, near its origin. It is present in both sexes, but much more developed in entire males who inflate it as a part of sexual display (Figure 11). The diverticulum is based on loose connective tissue and mucous glands are present. The exact method of inflation is not well understood. When inflated, most commonly during the breeding season, the dulaa projects from the side of the mouth as a rather dramatic, pink to red, balloon-like structure. Reports indicate that majority of male camels display the dulaa at the right side of the mouth. Young bulls and some females can produce the mature bulls gurgling dulaa rattle but neither can produce the full male display, complete with bubbly saliva. The Bactrian camel does not have a dulaa.

Surgical removal of the dulaa is undertaken when it is believed to be causing airway obstruction. The operation is carried out with the camel sedated with Xylazine and Ketamine.

Q. Describe the salient features of courtship and mating behaviour in camel.

During oestrus the female will seek the bull camel, may even sit in front of him. However, the intensity of heat varies both individually and seasonally. It has been reported that 14, 31 and 55% of females exhibit weak, moderate and intense signs of heat respectively. Those in heat are restless, bleat frequently and actively try to get close to the dominant male. The tail is lifted and waved about and small quantities of urine are passed frequently. A foul smelling slight discharge from the vulva may be present. The vulva is relaxed and slightly oedematous. The bull camel tends to herd its females and constantly investigates their perineal regions. He displays ‘flehmen’, a typical behavioural pattern seen in ungulates. Receptive females are pursued by him and then one of them is forced down (Figure 12). Once in sternal recumbency, the bull will mount the female from the rear (Figure 13). Copulation act is indeed unusual in that it takes place with the female on the ground. The male rotates his penis until the vulva is found. During copulation the bull gurgles, froths and may even extrude the dulaa (soft palate). The whole sex act lasts on average for about 8 to 12 minutes. It usually consists of several entries and the male may exhaust himself on one female if he is not removed by the handler. If the female has conceived she will refuse to lie down and curl up her tail when approached by the male.

The earliest time tail lifting (curling) can be observed is 20-25 days after copulation, however, at this time it does not appear to be a reliable indicator of early pregnancy. If it still persists 2 months later, it is reliable. Mid-term pregnant females always show tail curling when approached by bulls.

Q. Write down the characteristics of semen of a dromedary.

The semen colour is usually creamy white but varies from light grey to milky. The colour is related to the density of spern (darker colours having more sperm) and is considered as an indication of potential fertility. The volume of a natural ejaculation can be as much as 15 ml but the volumes obtained using an artificial vagina or an electro-ejaculator are less. Motility varies from 60 to 80%. The proportion of females becoming pregnant from a single mating early in breeding season may be lower as fewer sperm are actively seeking the ovum. It is thus advisable to allow two or three matings at this time and reduce the number later on. Comparatively older males are always likely to get a higher proportion of females pregnant than younger males with lower sperm counts and smaller ejaculate volumes. The total length of camel spermatozoa is short and is usually less than 50 µm. The head is ellipitical. Abnormal sperm are uncommon. Semen collection using an artificial vagina is not always successful but electro-ejaculation is a sure way of obtaining semen. A bull in his prime, 7-13 years old, can serve up to 50 females during one breeding season.

Q. Describe the anatomy and physiology of genitalia of a female camel.

Anatomy: The vulva is 3 to 5 cm deep with thick velvety lips, the clitoris being very small. The urethra is short and the opening in the bladder for the passage of urine is very narrow. The vagina is 30 to 40 cm in length and lined with mucosal folds. It is wide and as pregnancy advances, it extends and mucosal folds stretch with increasing weight of the uterus. The cervix consists of outgrowth ridges arranged in three or four rows. The oviducts, 17 to 28 cm long, follow a tortuous course to the horns but more so in the ovarian part of the fallopian tube and the ampulla than in the isthmus. Unlike other mammals, the oviducts are enlarged at the uterine end. This unique arrangement allows large numbers of spermatozoa to be stored for a long time. This arrangement increases the chance of conception and of reproductive success.

The camel has a bicornuate uterus, which is T-rather than the normal Y-shaped. The body is short, reddish in colour and smooth, the left horn being longer than the right. The uterus is usually attached low in the abdomen and it increases in weight during follicular activity. The ovaries are flattened, consist of a series of lobes and are reddish brown in colour. Each is enclosed in an ovarian bursa. The size of the ovary is 15 mm x 30mm. Non-functioning ovaries may weigh as little as 3.7 g, those with Graafian follicles 5.5 g and those containing a corpus luteum of pregnancy about 8 g (Figure 14).

Graafian follicles occasionally persist into pregnancy but in non-pregnant females are distributed randomly over the ovarian surface. They are opaque and spherical and up to 18 mm in diameter. Ovarian activity is related to the development of the follicles rather than to that of a corpus luteum, which is usually present only when an animal is pregnant.

The udder has four quarters, the front two being separated more distinctly from each other than they are from the two smaller rear quarters. The udder is covered by a thin black skin. The teats are small and each has two small openings.

Physiology

The Follicular Wave: The regular and recurring hormonally controlled sequence of events which ends in automatic release of an ovum (or ova) is in a way known as the

oestrous cycle. The term oestrous cycle thus correctly refers to animals which are spontaneous ovulators, this type of ovulation being the norm in the majority of animals. In a few mammals, including cats, the rabbit and the camel, the breaking open of the follicle to allow the release of the egg does not occur spontaneously and some kind of stimulus is required to induce release of the ova. This type of cycle involving reflex or induced ovulation is known as follicular wave.

In spontaneous ovulators, the oestrous cycle consists of four distinct phases known as pro-oestrus, oestrus, met-oestrus and di-oestrus. In induced ovulators, and specifically in the camel, there are also four distinct phases. The four phases of the follicular wave in camels are:

i) The mature follicular stage is equivalent to oestrus or heat in other farm animals. The camel may not be considered to be in continuous oestrus in spite of the fact that ovarian maturity is follicular. Female camels accept the male only during the mature follicular stage. Camels should therefore be watched for signs of heat and mated only at that time (in this respect it is an interesting fact that among some camel tribes in Eastern Africa, it is a common practice to forcefully mate female camels whenever a rutting bull is available. With this technique over 50% of the females are reported to get pregnant).

ii) The atretic follicular stage. The follicle regresses and becomes smaller in size. This stage starts if mating does not take place during the maturing follicular stage.

iii) The non-follicular stage.

iv) The growing follicular stage.

Q. What, generally, is the age of puberty in camels?

It is generally accepted that in camels the age of puberty, in both sexes, is 3 to 4 years. Pregnancy testing of 20 camels in Australia indicated that 6 herd mated animals 2 to 2.5 years old were in early stages of their pregnancy. The prepuberal gonads and genital tract have been reported to be responsive to the exogenous gonadotropic hormones. This property has been utilized in reducing the age of puberty and thus improving the reproductive performance of the dromedary camels.

Q. Discuss the peculiarities of breeding behaviour of one-humped camel.

Camels are seasonal breeders but male activity is more affected than that of the female.

Male: The seasonal breeding behaviour of the male camel is referred to as ‘rut’. It is mainly exhibited from mid November to the end of March in various parts of Indo-Pakistan subcontinent. Since geographical and topographical factors are involved, therefore rut is exhibited in the Southern Hemisphere during the months of May to October. It is generally first exhibited at around the age of 3 years. Males in rut become more aggressive and testicular size increases. In the presence of a female or another male in view, they stand with their legs apart, flick urine onto their back with the tail, froth at the mouth while making gurgling noises and protrude their dulaa. The poll glands become active and exudates a dark, acrid smelling secretion, which appears to attract females. Variations of this behaviour are used in the wild to repulse challenges from other bulls and protect the established ‘harem’. Rutting bulls also tend to be more aggressive to handlers and unpredictable in their general behaviour. Urine of the rutting

bull has high testosterone levels and some pheromones. Androgens levels in poll gland secretion are the same as those in the blood.

Males as young as 6 months may attempt to mount their recumbent mothers. Adult males may attempt to mate recumbent females even when they are not in oestrus. Some males may be fussy and refuse to mate with thin young females because of discomfort. Inexperienced bulls may be seen to attempt to mount from any direction, even over the female's head. This may induce the female to bite and occasionally inflict damage to the bull's genital organs. It is usual for the male to smell the vulva and urine, and react by lifting its head and elevating the upper lip (flehmen). Particular stimulus appears to be from pheromones in oestral urine. The male may wrestle uncooperative females to the ground, pin and choke her into submission with his neck over hers and then proceed with mating, always in the couched position. A bull in rut can serve 50 to 60 females in a season under controlled mating conditions, which helps prevent too much time being spent with each female, and provided he continues to eat well and hold his condition. Reports from Australia indicate that it is common to observe bulls in very thin body condition at the end of the breeding season. Apart from the time spent in courtship and coitus, these animals have had to be constantly on guard against intrusion by rival males. Thus the time available for eating may be quite limited. The length of an individual bull's rut varies from 2 to 4 months, which may depend upon the availability of feedstuff and various social factors. A bull that was dominant early in the season may be weakened and driven off by another bull later in the season.

The rut may be induced early or extended beyond its course by the use of hormones. Gonadotropin releasing hormone (GnRH e.g. Receptal 10 ml) given IM 2 to 3 times daily for three days then once daily for 4 to 5 days usually induces signs of rut. During rut libido may be improved by the same daily dose of GnRH, reduced to every second day for 2 to 3 weeks when the response is established. The use of GnRH is preferred to testosterone, which tends to accentuate aggressiveness.

Female: Females kept separate from males will make a gurgling call, almost like that of the male in rut, when she is ready to mate. She will get as close as possible to the male as allowed by the situation. For controlled mating the traditional procedure is to take the female to a sandy location and couch her with her head slightly down hill if possible. About 50% of females ready for mating will couch spontaneously as the male approaches. Others, especially young animals may have to be forcibly restrained in couched position with the front legs hobbled together across the animal's neck. In a free mating situation, the male will dominate by wrestling the female to the ground. Coitus takes place with the female in the couched position. The male covers the female by placing a front leg each side of the female's hump, his pedestal on her dorsal midline behind her hump and crouches back and down into the coital position. Depending upon the relative sizes of male and female, the front feet of the male may or may not reach the ground.

The process commences with the bull making forward probing, thrusting movements with hips. To save time and prevent contamination during hand mating, it is usual for an attendant to grasp the penis and direct it through the vulval labia. In the wild intromission

may take some time to establish. Coital activity then proceeds with short thrusting bursts punctuated by longer periods of inactivity. Some bulls are more vigorous than others. Some older bulls tend to just crouch and do very little. Coitus may last from 3 to 30 minutes, but averages 8 to 12 minutes. Over vigorous or rough, heavy bulls can cause dislocation or fracture of the female's sacrum. Some physical stimulation of the female appears to be necessary for ovulation to occur. Artificial introduction of semen into the female genital tract does not stimulate ovulation.

Q. Discuss the normal increase or decrease in certain hormones in the rutting period in the camel.

The rutting period in male has many physiological and behavioural peculiarities. There are significant increases in FSH, LH, testosterone and cortisol during the rutting season. The male camel loses a considerable body weight (up to 25%) during this period because its sexual activity distracts him from normal feeding.

Gonadotrophin-releasing hormone (GnRH) is a deca-peptide hormone secreted from the hypothalamus in a pulsite manner. Its synthesis and release is affected by season, photoperiod and endocrine status. It acts on the pituitary gland to stimulate release of LH and FSH, in a ratio influenced by the feedback effects of steroid hormones. Sexual activity in normal male camels outside the breeding season could be stimulated by GnRH treatment. It is also possible that the pheromonal 'male effect' may induce female camels to cycle earlier in the breeding season. There also appears to be an alteration in the semen consistency with GnRH administration.

In the non-breeding season hyperprolactinaemia accompanied by decreased serum levels of FSH, LH, testosterone and cortisol has been observed in Arabian camels. It seems that hyperprolactinaemia is a causative factor of low fertility and libido in the male camel during the non-breeding season. This is probably due to its action in reducing the synthesis and secretion of FSH and LH. There is also a possibility that prolactin has an anti-gonadotrophic action at the gonadal level. In the male camel, as also in other species, instances of lack of sexual desire and inability to copulate during the rutting season have been observed. Because of comparatively lengthy act of copulation, and the fact that several ejaculations may occur during mating, wide variations in ejaculate volume and in sperm concentration and motility have been reported. Thus poor semen quality could be a cause of herd infertility under range conditions (Chaudhary, 2000).

Protrusion of the soft palate in camel is observed in the rutting season, but it is not extruded in the female. Erection of the penis does not occur during courtship in the standing position, which indicates that foreplay and a set period of time for full arousal are not necessary for successful breeding in the camel.

Q. Give below the salient characteristics of semen of one-humped camel. Indicate the sperm concentration for artificial insemination.

Considerable variation in the semen characteristics of Arabian camel have been reported. The semen is greyish-white in appearance and total volume ranges from 2 to 8 ml. Sperm concentration ranges from 256 to 440 X 10^6 per ml. Sperm motility in raw semen examined 15 minutes after collection ranges from 30 to 50% and motility may be

preserved best at room temperature by diluting the semen 1:2 in skim milk/glucose diluent containing antibiotics.

Good quality semen to be used for artificial insemination in camels should have at least sperm concentration of 325 to 331 X 10^6/ml and sperm motility of 49.5 to 50.5%. The proportion of dead spermatozoa should not be more than 18 to 19%, sperm showing morphological abnormalities 27.7% and sperm showing acrosome abnormalities 8.5%. The sperm concentration is usually measured with haemocytometer. The sperm motility is evaluated using phase contrast microscope at a magnification of X 128, slide being put on a warmed stage (38°C), standard commercial stains such as Krass for examining morphology and Eosin colour test of Bartmann for recording percentage of dead spermatozoa.

Q. What do you think is the optimum time and proper site for artificial insemination in the Arabian camel?

Proper time for artificial insemination involves the time during an oestrus period best suited for the successful union of the ovum and the sperm cell as well as the optimum cyclic conditions of female reproductive tract. It is recommended that the optimum time for insemination with fresh semen is first day on which the camel shows signs of oestrus, ovulation usually occurs 24 to 36 hours later. When inseminating with frozen semen, it is good to inseminate twice 24 hours apart, so as to be sure of supplying ample ovulation inducing factor. Best results have been obtained when inseminated 24 hours after mating with a vasectomized male.

Artificial insemination in the camel is either vaginal or uterine. The uterus is bicornuate. The cervix is dilatable and two fingers can easily be inserted into it at the time of follicular activity. This indicates an easy by pass of cervix by AI gun for insemination or for embryo transfer. The incidence of ovulation after deep vaginal and uterine inseminations was reported as 87 and 100% respectively, showing the possibility of higher conception rate with uterine insemination in the camel. The camel is inseminated restrained preferably in sitting position. However, some authors inseminated camels in standing position using a mare inseminating catheter, guided through the cervix by manipulation per-rectum (Chaudhary, 2000).

Q. Discuss infertility in one-humped camel.

The fertility of she camels is maintained almost throughout their lives and breeding in alternate years is the usual practice. The fertility of female camels is apparently high and the herd owners claim that 80 to 90% of those mated in one season produce calves. A similar fertility rate has been reported in herds managed intensively. The abattoir studies confirmed that the structural defects of the genitalia, including cystic ovaries and ovariobursal adhesions are relatively rare. Endometritis associated with a partially involuted uterus and a regressing corpus luteum is sometimes seen. The fertility in the pastoral herds of camels is unlikely to be more than 50%, or up to 65% under improved management. It has also been seen in field studies involving a large number of Asian and African countries that delayed puberty (first pregnancy at 5 years of age), long interval between births (>24 months) and early culling of breeding females limit the average production of calves to less than three per female. Anoestrus, due to malnutrition or

debilitating diseases, is probably a major cause of infertility. Embryonic death is known to occur, especially in twin gestations. Poor nutrition and trypanosomiasis are probably responsible in part for the embryonic deaths.

Reports of bacterial infertility in female camels are scant and most investigations have been done in slaughtered camels with no previous breeding histories. *Corynebacteria, Anthraxoids, Micrococci, Sarcina* and gram-negative bacilli were isolated from the normal genital tract of pregnant and non-pregnant slaughtered camels. Other bacterial species such as *Staphylococcus epidermidis* and *Escherichia coli* were also identified.

Q. Discuss pregnancy in dromedary, giving details of implantation, foetal development, duration and diagnosis of pregnancy.

Ovulation occurs about 30 hours after coitus. After fertilization in the fallopian tube, the embryo enters the uterus 5 to 5.5 days after ovulation. Unfertilised ova degenerate in the fallopian tube as in the mare. The conceptus is visible ultrasonically at 17 to 18 days and is elongating by day 20. Migration within the uterus is common and 7 to 9 day embryos placed into right horn will migrate to the left. Nearly 99% of pregnancies occupy the left uterine horn. Implantation occurs at about day 14. Placentation is diffuse and epitheliochorial, as in the mare. The camel, however, has three foetal membranes. In addition to the allantois and amnion, camelid foetuses are enveloped, except at certain points, by a closer epidermal membrane. This third membrane permits the lips, genitals, anus, teats and hooves to have access to the amnion fluid.

Foetal Development: The camel embryo elongates quickly and soon protrudes from the left horn onto the right uterine horn. Videoscopic studies showed allantochorion to be in left horn at day 20 which extended into the right by day 25. Examination at day 44 showed the exposed surface of the allantochorion to have a roughened and hazy appearance, presumably due to the development of simple chorionic villi in the process of implantation and placentation. When examined by the transmission electron microscope, these villi are present on the trophoblast cells of embryos as young as 7 days. At 44 days the tail and four limb buds are visible on the foetus and the head, eye, umbilical cord and heart beat are discernible. At 55 days the allantochorion is thickened and spotty and presses on the internal os of the cervix. The foetus is clearly seen to have rudimentary bones and a more camel-like head and neck. Blood vessels are also more developed by now. When the FBL (foetus body length) is 1 to 10 cm, the allantoic fluid volume is 1.5 litres. When FBL is 90 cm, fluid volume is 5 to 6 litres and finally reaches about 8.5 litres when the FBL is 100 to 107 cm. The fluid resembles pale urine. When the FBL is 0 to 10 cm, the volume of amniotic fluid is 13 ml. It increases to a volume of about 1 litre at parturition. The fluid may be watery or cloudy due to the presence of meconial debris.

The extra close fitting of epidermal membrane becomes apparent when FBL reaches 41 cm. It closely envelops the foetus but leaves the orifices open to the true amnion. It appears to be a major source for the relative ease of birth in the camel.

Duration of Pregnancy: It has a range of 370 to 405 days with an average of 388 days. The period of gestation for female calves averages at 390 days, while for males 385 days. Lower limit for survival of foetus is 350 days. Calves born at or just before this time may appear weak but otherwise normal for the first 24 hours post partum but then go into

irreversible decline surviving only for 2 to 3 days. Average pregnancy duration in the Bactrian is about 400 days.

Signs of Pregnancy and Diagnosis: An evident sign is that the pregnant female is no longer receptive to the male. She will try to repulse close male attention by biting. A pregnant dromedary exhibits the tail up reflex after about 15 days. The reflex can vary in intensity from a tail held just above horizontal to an almost vertical tail, exhibiting tremor. The reflex is elicited by the approach of a male. The inexperienced observer can confuse the reflex with a tail up response to fear. The tail up response due to fear usually has no tremor. The true tail up reflex appears to depend upon the presence of a corpus luteum. It is also present in a female treated with hCG (human origin chorionic gonadotropin) and in females treated with natural progesterone, 100 g once daily for more than 4 days. When hormonally induced, the reflex does not persist for more than 18 to 20 days.

Accurate diagnosis is based upon manual and/or ultrasonic examination per-rectum. Manual examination can be performed in the dromedary at 45 to 50 days and in the Bacterian at 30 days. Workers at the SCRC (Dubai) has recently established the ultrasonographic appearance of the grvid uterus and foetal structures from 17 to 320 days of pregnancy, using a 5MHz probe on an Aloka machine. Pregnancy can be diagnosed as early as 17 to 18 days when a non-echogenic space (fluid filled) 10 to 15 mm long and 4 to 6 mm wide will be seen. At 20 days, the embryo within its spherical, fluid filled yolk sac can be seen and the heart beat is discernible. At 26 days the conceptus occupies the entire left horn and the allantois is visible. The enlarging allantois forces the embryo dorsally within the vesicle until the 35th day, after which the yolk sac is sufficiently incorporated in the developing umbilical cord to allow the foetus to move towards the ventral uterine wall again. Blood progesterone assay has also been used for pregnancy testing in the dromedary. Persistence of a level >1ng/ml after day 12 (post mating) is considered a strong indication of pregnancy. Generally, however, progesterone assay has a limited application in reproductive management in the dromedary.

The birth of twins is rather rare in camels (Manefield and Tinson, 1997).

Q. What is the usual frequency of embryonic resorption in dromedary?

Almost 10 to 15% of camels diagnosed pregnant at 20 days are found to have lost the embryo by day 40. The reason for this resorption is not understood. Since the persistence of the corpus luteum appears to maintain the pregnancy throughout the gestation period in camel, therefore it is not likely to be due to change over to placental control. The resorption rate has been reported to be the same following both natural and embryo transfer pregnancies.

Q. What are the salient signs and various labour stages observed in the process of parturition in the camel?

Varying degrees of abdominal distension are exhibited by camels when they are close to parturition. Some breeds show considerable enlargement from about 6 months. Other more reliable signs are udder enlargement with the presence of colostrum and varying degrees of oedema, vulval oedema during preceding 5 to 7 days, sacrosciatic ligament

relaxation in the preceding 10 to 14 days. Signs of imminent parturition are restlessness, the tail carried in a horizontal position, voluntary isolation if permitted by situation.

The first labour stage may have a duration of 5 to 24 hours and is characterised by restlessness, the tail being held almost continuously horizontal, frequent passage of small quantities of urine, frequent couching, rising, rolling, straining commences during the later part of this stage. The second stage marks the appearance of the intact allantochorion at the vulva or a discharge of fluid from its prior rupture. Strong expulsive efforts made and may be some struggling type discomfort shown by primiparous animals. The foetal nose appears at the vulva with the head resting on or between the front legs. Posterior presentations are very rare. The foetal expulsion takes about 20 to 40 minutes. In the presence of the normal lubricating foetal fluid, the camel foetus presents less problems for expulsion. The additional epithelial membrane enveloping the camel foetus may have a significant role in this respect since it is highly slippery when lubricated with amniotic fluid. Primiparous females usually complete the second stage of labour in the standing position. They wander around as if they do not quite known what to do. The calf from these animals is literally dropped into the world and as a result the umbilicus breaks earlier than is usually the case. Total volume of foetal fluid is about 9 litres, of which 80 to 90% is allantoic fluid. It is fairly established that amniochorionic sac ruptures first in the Bactrian but some authors opine that the allantochorionic sac ruptures first in the dromedary, as is the case in the mare and the cow.

The third labour stage covers the events from birth to expulsion of placenta (foetal membranes). This stage on average occupies about 30 minutes. Apart from the case of primiparous animals, rupture of the umbilicus occurs when the calf vigorously moves away or the mother stands. Camels do not eat the foetal membranes. The mother nuzzles and prods the newborn rather than to lick it in the fashion of other species. The calf takes on average 30 minutes to 1 hour to stand up and time to first suckle is between 1.5 and 2 hours. Within a few days it is able to follow its mother.

Retention of placenta beyond 12 hours is unusual. When necessary manual removal may be resorted to after injecting 1M, 5 ml of oxytocin. Removal of placenta should be followed by insertion of antibiotic pessaries (e.g. Utozyme foaming pessaries).

Q. What percentage of difficult births are encountered in camels? What precautions and procedures need to be adopted in dystocia cases in camels?

Although the camel foetus has long legs and neck yet only in about 1% of births difficulty is encountered. Such cases are on record where live calves have been delivered after 12 hours of stage 2 labour. Of course, unnecessary delay is not advisable, yet it is suggested not to interfere until stage 2 has been in operation for at least 1 to 2 hours without any visible progress.

The most dangerous dystocia case is that when the foetus is so retained that presence of its nose or limbs within the cervix does not reflexively stimulate voluntary expulsive efforts. In such cases the pregnant animal may become comfortable and resume feeding. Thus if preparturient females are not under adequate, quiet surveillance by experienced personnel, dystocia in these animals may be missed until they show up as very ill, toxic animals, retaining decomposing foetuses. As a precautionary measure, plenty of

unobstrusive observation is the key to this problem. Binoculars can be an invaluable aid. Once the placental sac is visible or ruptured, the camel should be examined, if there is no progress for foetal delivery within an hour, regardless of the expulsive effort or lack of it. When it is decided to manually examine the animal, she should preferably be restrained in stocks, since any malposition is rather easily corrected in the standing position. If stocks are not available, some sort of hobbles should be applied to ensure that all kicking is controlled. If it is impossible to examine the animal in standing position then she may be couched, but it makes the obstetrical procedures very difficult.

The perineum of the animal is thoroughly cleaned and washed with a mild disinfectant solution. The obstetrician should wash his hands and arms in a fresh bucket of similar mild disinfectant. Any loss of natural birth lubricants due to use of soap, can be counteracted by the use of K-Y jelly or obstetrical lubricant. Obstruction to foetal expulsion should be removed by correction of malpresentation or any parturient problem. When the foetus is dead, in cases such as extreme lateral neck allows limb traction to deliver first the foetal body and the severed head and neck later. When foetus is alive and correction and vaginal delivery do not seem possible then a caesarean section should be performed.

In an anterior presentation, delivery may be assisted by applying traction to both legs and head. Obstetrical soft ropes should first be applied above the fetlock and then a half hitch thrown around the pastern. Thus the traction load is shared between the metacarpus/metatarsus and the pastern. This helps avoid fracture of the metacarpus/metatarsus and damage to the fetlock joint. The head rope should noose with its loop placed just to the ears and the sliding portion within the mouth. Main traction should be applied first to one leg then the other, while moderate tension on the head rope prevents the neck from bulking within the canal.

Q. Give the procedure to perform caesarean section in the camel.

Instead of risking the life of a valuable calf through prolonged obstetrical manipulation, it is better to subject the camel to caesarean section and save the calf as well as the mother. The operation is preferably performed with the camel in sternal recumbency until the uterus is sutured. If, however wound tension indicates, the animal may be placed in lateral recumbency for abdominal closure. Xylazine and Ketamine are used for restraint and analgesia, whereas the incision line is inflilitrated with a local anaesthetic. Some operators use epidural anaesthesia to immobilize the tail and to minimize voluntary straining due to cervical stimulation. Before the laparotomy incision is made in the left flank, the whole area should be shaved, washed with povidine iodine scrub and then liberally painted with pyodine. The use of drapes depends upon the choice of the surgeon (Manefield and Tinson, 1997).

The laparotomy incision should be 25 to 30 cm long. Some surgeons commence the incision 8 to 10 cm below the lumbar transverse processes and proceed vertically downwards about 10 cm caudal to the last rib. The muscle wound is best made as a straight cut in a vertical wound since it provides better access than developed splits. With the oblique incision the opening may allow a split in the external oblique muscle and the others are cut. Whatever the technique used, the surgeon must take pains to protect

spleen, which in the camel is attached to the caudolateral aspect of the rumen. The gravid uterus should be identified by palpating portions of the calf through the wall of the uterus. The preferred uterine incision site is around its greater curvature to avoid large blood vessels. The incision area should be brought as close to the wound as possible. If the incision site can be exteriorized, spillage of uterine fluid into the abdomen can be largely avoided. On many occasions, because of the mass involved, it is not possible to achieve the ideal exposure. If the use of a scalpel within the peritoneal cavity is deemed to be unsafe, the uterus may be penetrated and opened using straight Mayo scissors. Before taking up uterine closure, the placenta should be freed from the vicinity of the wound to avoid its being penetrated and caught by the sutures.

In case the placenta is relatively loose, it can be freed and removed but remember that surgical time should not be unduly prolonged. Also, any attempt at removal should cease if haemorrhage is induced. Initial closure of the uterine wound is achieved by a simple, continuous, right through suture of size metric 7 chromic gut. This prevents the mucous membrane retracting from the wound and gives good control of haemorrhage along the wound edge. Just before closing, an antibiotic foaming pessary may be inserted into the uterus. A second suture tier of continuous horizontal mattress, Lembert or Connell pattern is placed to strengthen and seal the wound. Heavy chromic catgut of size metric 7, is used to separately close the muscle layers of the abdominal wall. Some surgeons prefer a single tier of interrupted horizontal mattress sutures. Some tension may be experienced in closure of the wound with the camel in sternal recumbency. Some surgeons therefore advocate performing the entire operation in right lateral recumbency. Those who prefer the sternal position can reposition to the lateral to facilitate closure if they like.

Q. Discuss the possibility of the use of artificial insemination (AI) in camel breeding.

There are owners who may be reluctant to travel their good bulls to other places for breeding; some may have injuries that make natural mating difficult to impossible. AI can overcome these constraints. Also, the breeding worth of bulls may not be known until they are 7 to 8 years old, the freezing of semen and use of AI can insure against premature loss of the animal. With AI one bull is able to get more females pregnant within one breeding season. Genetic material can be transferred to places where it is not possible to transport the male animal(s). Semen for AI may be used fresh or frozen. The major constraint to successful AI is that the camel is suspected to be a coitally induced ovulator.

The visual signs of oestrus in the camel can be described as erratic. Therefore, it is advisable to inseminate when ovulation potential is optimum, as determined by rectal palpation and preferably by ultrasonic examination (Manefield and Tinson, 1997). The female is presented for insemination in suitable stocks or restrained in couched position. The perineal region is cleaned and dried. The semen containing 300 to 400 million motile spermatozoa is introduced into the uterus. Frozen straws should be evaluated after thawing and the number of straws required for insemination calculated. After deposition of the semen, a dose of human origin chorionic gonadotropin (hCG) e.g. Chorulon, 300 IU, IV, is administered and insemination may preferably be repeated in 24 hours. An

alternative more suitable for field conditions is to administer a dose of prostaglandin F_{2a} (e.g. Estrumate, 2 ml) and equine origin chorionic gonadotropin (eCG) e.g. Pregnecol, 2000 IU, IM, and wait for 9 to 10 days then inseminate and give hCG, the luteinising hormone. By increasing the likely number of follicles of ovulatory size being present, the eCG increases the likelihood of a mature ovum being released when luteinising hormone is administered. If the site of the follicle with best ovulation potential is known, the semen should be deposited into the ipsilateral (on the same side) horn. If multiple follicles are present, may be as a result of eCG administration, it is just as well to deposit the semen into the body of the uterus. If the animal can be examined 48 to 72 hours after the hCG administration and no ovulation has occurred, then an increased dose of hCG (Chorulon, 5000 IU, IV) with GnRH (gonadotropin releasing hormone) e.g. Receptal, 5 ml, and a further insemination is required.

Q. Describe the procedure of embryo transfer in one-humped camel.

Genetic improvement by natural breeding in camel is very slow. Even the traditional camel societies are in search of ways and means that can enhance the reproductive performance of their camels. Multiple ovulation, embryo transfer (MOET) programme, though currently beyond the means of a common man and not cost effective, offers a technique that can help overcome the constraints to the improvement of desired traits. Manefield and Tinson (1997) have described the procedure as given below:

It is common to recover 10 to 15 embryos per collection from a good donor (29 were recovered in one case). In programmes where 40 donors are matched with 160 recipients, it is possible to achieve 10 pregnancies per donor within one season for 20 to 25% of the donors flushed. This is equivalent to 20 years natural breeding potential for each successful flushing. In case of very valuable camels that only provide two embryos, the normal breeding rate may be at least doubled, and therefore, the result is considered acceptable. Two breeders working on a cycle of one month, can match 40 donors to synchronise with 160 recipients and collect and transfer >200 embryos. It is possible to repeat this cycle 4 times per breeding season with the use of 40 to 50 additional recipients for each cycle. Pregnancies up to 145 per season can be expected.

Superovulation (SO): It is achieved by injecting FSH (e.g. Falltropin-V; Embryo-S) or eCG (e.g. Pregnecol; Folligon) following natural progesterone in oil (e.g. Bomagest-E; Progesterone; Progestin) 100 mg once a day for 14 days. Response to the various FSH preparations can vary from camel to camel. The usual dosage schedule for Fallotropin-V at a dilution of 20 mg/ml is: day 1 and 2, 3 ml IM twice a day; day 3 and 4, 2 ml IM, twice a day; day 5, 1 ml IM, twice a day; day 6 and 7, 1 ml IM, once a day. The ovaries are examined ultrasonically on day 8 and the usual time of mating is day 9 to 10. Most camels produce embryos, but number and quality varies. No adverse long term effect of 50 has been noted. After repeated 50, camels have been allowed to undergo a natural pregnancy and successfully returned to the MOET programme later. Likwise donors can be used year after year depending upon their continued response to 50 and value to the programme.

Time of Mating: It is determined by ultrasonic examination and the female is served twice with a 12 hour interval when follicles of 12 to 18 mm diameter are detected. This ensures best ovum maturation and ovulation.

Embryo Collection: Embryo collection is first performed 7 days after mating and repeated 12 to 24 hours later. The donor female is restrained in a suitable set of stocks. After thoroughly cleaning the perineum with a Savlon solution and towelling off the surplus, a silicone rubber Foley catheter is introduced and inflated in the cervix. This operation is assisted by employment of a fine metal stilet within the catheter. The operator puts on a long rectal glove with fingers cut off and a sterile surgical glove over this. Care must be taken to determine that the cuff inflated with 40 ml of air, is situated within the anterior cervix. The body of the camel uterus is so short (2 to 4 cm) that placement therein may occlude one horn and so prevent a complete simultaneous, bi-cornuate flush.

Flushing is accomplished by connecting a ‘Y’ shaped Vigro Bovine Uterus Tube Flushing Set to the flushing fluid reservoir (plastic bag) and the Foley catheter in the manner shown in Figure 15. This allows fluid returning from the uterus to pass through a 75 micron embryo filter. Clip 1 (C1 in Figure) is opened and the flushing fluid bag is squeezed to fill the uterus, as judged by the operator’s finger against the cervix and catheter bulb per vagina. Clip 1 is closed and clip 2 (C2 in Figure) is opened to allow the uterus to empty. The process is repeated until the flushing fluid is exhausted. Once the flush is satisfactorily established, with no cervical leakage, the operator may insert an arm per rectum to determine that both horns are being well flushed, that the horns are not being subjected to excessive fluid pressure and he can massage the organ to assist fluid recovery. Overfilling the uterus can result in endometrial tearing and a blood contaminated flush, complicating the identification and washing of the embryos. The clip below the embryo filter (C3 in Figure) is opened periodically to prevent the filter from overflowing, but also so that at all times during collection, the cup fluid level is maintained at about one-third full. For protection and continued viability of embryos, it is important to keep them totally immersed in fluid. The following two flushing fluids have been found to be satisfactory. I) Vigro Complete Flush Solution, 2) Dulbecco’s Phosphate Buffered Saline, which includes Kanamycin 25 mg/litre and 20 ml of Bovine Serum Albumin is added to each 1 litre bag.

After flushing has been completed, the fluid in the cup above the filter grid, containing the embryos, is transferred into a gridded (having horizontal and perpendicular lines) petri dish. This dish is scanned with a stereo dissecting microscope. As each embryo is found it is picked up by a pipette and transferred to a drop of filtered holding fluid, which is one of 5 separated drops in another petri dish. Within this drop the embryo is flushed up and down 2 to 3 times. This ‘washing’ process is repeated sequentially through the rest of the drops until after the 5th rinsing, there is no debris in the drop or attached to the embryo. As each embryo is washed, it is placed in a filtered holding solution ready for grading. This solution may be Vigro HEC-2 or may be prepared by adding 1 ml of foetal calf serum to 9 ml of flushing fluid. It is filtered through a 0.2 mm Naglene filter. The embryos are graded 1 (excellent) through 5 (dead) using the usual criteria of shape,

colour, dead cells, compactness and shape of blastomeres in the early morula, amount of perivitelline space, cracks in the zona, definition of trophoblast border and presence of tightly adherent debris. Grading can vary a little because of its inherent subjectivity. Camel embryos do vary between animals and between flushes, but a large majority rate between 1.5 and 2.

Recipient Preparation: Ideally, recipients should be selected from young camels, preferably from maidens, that have uteri free from all pathology. Parallel with the SO of the donors, the recipients are given 100 mg of natural progesterone in oil once a day (e.g. Bomagest E; Progesterone; Progestin) for 10 days followed by Pregnecol, 1500 to 2000 IU and 2 ml of Estrumate on day 11. This is done to ensure creation of follicles and hence a CL (the better the luteal material, the better are the chances of pregnancy). Ovulation and luteinisation is induced in the recipients by giving them Chorulon, 3000 IU IV, 24 hours after the donors receive the same. Thus an attempt is made to have CL's in the recipients that are one day younger than those in the donor. Best results have been achieved when the matching of recipient to donor is minus 12 to 36 hours.

Non Surgical Embryo Transfer: For transfer, embryos are loaded into straws and these into an embryo transfer gun. The whole procedure and apparatus are similar to that used for AI in buffaloes and cattle. Place of the embryo should be at the tip of a uterine horn. Left or right horn, placement results in a similar pregnancy rate. Almost 99% of camel pregnancies occupy the left horn, but embryo migration from the right takes place regularly. Otherwise pregnancy rate will depend upon the grade of the embryo, the health of the recipient's reproductive tract and the degree of synchronization that has been achieved. In small groups when grade 1 embryos are transferred fresh to grade 1 recipients, a pregnancy rate of 65% can be expected. Maiden camels aged 5 to 6 years have proved to be the best recipients. In larger groups this rate falls to 50%. With cryopreserved (maintaining viability by storing at very low temperature) embryos, only 15 to 20% of transfers result in pregnancy.

Surgical Embryo Transfer: The recipient camel is held in stocks and sedated with 0.15 mg/kg of Xylazine and Ketamine IV. An incision line is infiltrated with a local anaesthetic and surgical transfer of embryo is made through a 20 cm horizontal incision 5 to 10 cm cranial to the iliac crest, in the left flank. The muscular opening is by muscle split and the tip of the left uterine horn is exteriorised. A small punch (an instrument for perforating or excising a segment of a tissue) incision is made in the outer uterine wall. Through this a transfer gun with a 10 ml sterile glass pipette containing the embryo is 'popped' through the endometrium, slipped along the lumen and discharged. The laparotomy is routinely closed. There is some difficulty in exteriorising the uterine horn in maiden recipients. Therefore, animals that have already had one calf are better. One surgical transfer requires about 40 minutes and a non-surgical transfer requires about 15 minutes. The rate of pregnancy for both methods was 33%, at the time it was done. Since then non-surgical transfer pregnancy rate has risen to 50%. Since surgical transfer method has produced no better results, is slower and more labour intensive, therefore it has been abandoned.

Q. Write a note on progesterone and estrogen levels in camels at oestrus.

Progesterone levels in camels at oestrus are about 0.5 ng/ml, while oestrogens are at peak of 75 pg/ml. The level of oestrogen rises to 3.5 ng/ml at days 3 to 6 and then to a peak of 4.5 ng/ml at day 9 in mated camels; it then falls rapidly again. Oestrogen levels drop to 15.1 pg/ml at the first stage and remain low. The concentration of luteinizing hormone rises rapidly to a maximum of 6.9 ng/ml from a basal level of 2.7 ng/ml, starting one hour after coital (or other) stimulation, reaches a peak at three hours and remains high for about 10 hours. Ovulation takes place 36 to 48 hours after mating. These variations in level can be used to determine the best time for mating to take place.

Q. Do you think that camels (one-humped) are polyoestrus? Discuss in detail.

It has long been accepted that camels undergo several cycles, which follow each other; they are in fact polyoestrus animals. It was long thought that oestrus occurred only at certain times of the year. However, it is now known that in most areas follicular wave activity does occur all the year round. In areas having marked weather changes among the season, follicular activity is at its greatest in winter and spring and the total cycle is longer at this period. During the summer, the phase lasts only for a very short time and the growing follicular stage is relatively long.

In Egypt, the mean duration of the follicular wave is 24.2 days with oestrus lasting 4.6 days within a range of 0 to 15 days. In Sudan, the length of the wave is 28 days with oestrus lasting 4 to 6 days within a range of 1 to 7 days and in India the wave is 23.4 days and oestrus averaged 5.0 days within a range of 3 to 6 days. In all areas the natural mating season is at that part of year when the follicular wave is the longest. Most conceptions occur at this time. Long cycles are certainly associated with environmental conditions, including lower temperature and better nutrition. Mating seasons can probably be prolonged or even made to be year round if feeding and other management factors are adjusted to ensure that conditions are appropriate for the longer cycles.

Q. What is frequency of occurrence of dystocia and vaginal prolapse in camel?

The incidence of malpresentation is quite low. Most commonly lateral deviation of the head and carpal flexion have been observed. A high incidence of post partum injuries such as vaginal tears, complete rupture of the perineum and vulva and posterior ataxia are seen in heifers bred too early by a large sized bull. Faulty laymen assistance may also cause lacerations by applying too much traction when removing the foetus. Vaginal prolapse is a quite commonly seen condition related to vigorous laymen assistance during delivery. Untreated and neglected post partum injuries may result in permanent infertility.

Q. What may be an appropriate age at first parturition in dromedaries? Give examples in this respect.

In traditionally managed herds in Kenya, camels first calved at an average age of 4 years and 10 months. In one of the studies in Niger, it was found that between 3 and 80% of females first gave birth at 4 to 5 years. About 95% had produced at least one young at 6 years, whereas one of these groups of camels did not produce their first young till 8 to 9 years age. A survey carried out among herders in Sudan indicated that 2% of females first had a calf at 3 to 4 years age, 10% at 5.5 years, 37% at 5 to 6 years and 51% at more than 6 years. At the National Camel Research Centre in India, age at first calving was reduced from 5 years 2 months in the period 1961-85 to 4 years and 1 month from 1986-90,

mainly due to the effects of better management. In the United Arab Emirates animals whose own birth dates were known were mated first at 3 years and 7 months and calved at 4 years and 7 months.

In summary, it seems that the management implications of this are clear: better feeding, improved health care and better overall management will enable camels to produce their first calf at a younger age and add to the total length of their breeding life. In traditional systems better feeding conditions may result from long-distance migration. In sedentary or modern systems, supplementary feeding in early life and keeping camel numbers down to the carrying capacity of the feed resource will help to lower the age at first calving. Further information on feeding to improve overall performance is given in chapter on Feeding and Nutrition.

Q. Write a note on traditional and improved parturition intervals in camels.

Most of the available information indicates that the interval between successive births in camels is about 2 years. However, under commercial ranch management in Kenya, the average of 460 intervals was 16.7 months. Most intervals averaged about 18 months but there were some at about 13 to 14 months and relatively few longer than 30 months. Parity did not have any real influence on the interval. An abortion or the death of the young before weaning led to a shorter interval to the next birth than if the young survived to weaning. This was probably because lactation stopped so the hormones controlling milk production which also suppress the reproductive hormones disappeared and allowed animals to start their sexual cycles again. Traditional systems in Kenya, however, do not aim for short intervals and breed their animals only once every two years and maintain a ratio of one breeding bull to 50 or more females.

In other studies, the interval between births has been established as 14.3 months in Najdi camels in Saudi Arabia and in commercial milk herds in the Al-Jouf region, a calving interval of 14-15 months has been obtained. In some areas of Saudi Arabia, females are run in two units, each of which is mated in alternate years; pregnancy rates are said to be 80 to 90% in each of the units (i.e. 40 to 45% annual calving rate).

The management implications thus are twofold: i) more calves can be obtained (i.e. intervals between births can be reduced) if the negative effects of the lactation hormones can be overcome. This can be done by removing the calf and causing its mother to dry off. The calf then has to be fed artificially of course, and ii) if the calf is not weaned, the effects of the lactation hormones are gradually suppressed by the reproductive hormones and the influence of these can be made stronger and earlier if nutrition is better. Supplementary feeding of the adult female camel will therefore also lead to better overall reproductive performance.

Q. Write a note on annual reproductive rate (ARR) and total lifetime production in one-humped camel.

In northern Kenya calving percentages of 21.1 and 47.4 have been reported for non-treatment and treatment herds. The ARR on commercial ranches in Kenya was 64%. In northern Niger, the ARR was calculated as 0.46 young per breeding female.

In Niger a total of 215 camels gave birth to 573 young or an average of 2.7 per breeding female in their lifetime. In Kenya the average lifetime production of young was 3.5 per

female on commercial ranches. At the India national camel farm, females gave birth to 2 to 8 young during their breeding life with an average of 4.49.

Q. Is breeding in all Asian and African camels confined to the same season as in Pakistan.

Data obtained from different areas show a marked seasonality, with most activity in winter. In Somalia there appear to be two main breeding seasons, related to two rainy seasons. In the United Arab Emirates most births are in October to January but a few in April and May, indicating the possibility of extending the breeding season if feed and management are adequate. In Kenyan traditional herds there is some breeding all the year round but greater activity in December/January and may possibly be associated with better nutritional status at conception (Table 9).

Table 9. Breeding seasons of the one-humped camel in various countries

Country	Breeding season
Pakistan	December-March
India	November-February
Somalia	April-May/June; September-November
Egypt	December-April; May-August
Sudan	March-August
UAE	October-January; limited April-May
Mali	February-March; August-September
Morocco	May-June

Source: Wilson, R.T. (1989). Reproductive performance of the one-humped camel: The empirical base. Rev. Elev. Med. Vet. Pays Trop. 42:117-125.

Q. Discuss very briefly camel genetics.

Camelids have a diploid chromosome number of 74. The karyotype consists of 33 pairs of acrocentric and 3 pairs of submetacentric autosomes, a large submetacentric ‘X’ and a very small acrocentric ‘Y’. The identical patterns in chromosome linear differentiation for the *Camelidae* suggests that their karyotype has been highly stable for millions of years. It probably represents the most extreme case of chromosome conservatism among mammals. Their identical karyotype, despite their longstanding geographical separation, would suggest that their early genetic make up was very adaptive and that any divergence from this was non adaptive and deleterious to survival. This is certainly interesting given the difference in the environmental influences on the Old World and the New World Camelids over the last a few million years, since their common ancestry in North America.

The close relationship of the Camelids is reflected in their ability to interbreed. All four species of the New World Camelids (llama, guanaco, alpaca and vicuna) can interbreed and produce fertile offspring. Crosses between the one-humped dromedary and the two-humped Bactrian are possible, the progeny having one long hump, but some F_1 males are reported as sterile. The chromosome similarities are there, but physical incompatibilities and gestational differences need to be overcome (Old World 385 days; New World 345

days). Despite gestational and physical differences, successful cross between a dromedary and llama has given birth to ‘Camella’ in Dubai under the supervision of Dr. Skidmore (2002). *Camelus dromedarius* appears to have a high degree of genetic polymorphism and that genetic probes and PCR (polymerase chain reaction) technology will be useful in determination of parentage and selecting for traits. Parentage of South American camelids can be determined with 95% accuracy on inheritance of blood groups, since they display types A, B, C, D, E and F.

The dromedaries only seem to share B with their South American cousins. At the Scientific Centre for Racing Camels (SCRC) in Dubai, blood groups and various enzymes were studied using electrophoresis to detect genetic variation. Unlike the New World camelids, the Old World camels showed no significant differences. DNA study was therefore undertaken. Initially RAPD (random amplified polymorphic DNA) was used to analyse the genome variation. This technique is based on the use of polymerase chain reaction (PCR) using short, single and random primers to detect variation, without prior knowledge of DNA sequences. A number of different markers have been studied and genetic variation in the camel has been demonstrated. This technique is also being used to look at the variation in subspecies or strains (e.g. Sudani camels compared with Emirati camels) to determine whether crossbreds can be identified accurately.

Some DNA finger printing on parentage in camels, using human minisatellite probes, 33.6 and 33.15 hybridised with DNA, has been tried elsewhere and has proved to be accurate. The technique can be very time consuming. Determination of parentage has been attempted at the SCRC using STR (short tandem repeat) polymorphic markers also known as microsatellites. The early results are encouraging. This technique could ultimately prove to be faster, more accurate and requires less DNA.

Q. Discuss in genetic terms that P=G+E, where P=phenotypic measurement of a trait, G =combined effect of all genes concerned, E= environmental factors influencing the trait.

Many traits of economic value in the camel are influenced by a number of genes, each of which has a relatively small effect. In other words, the traits are not influenced primarily by genes at a single locus. Such traits are called quantitative or multifactorial traits, many of which can be measured quantitatively e.g. the speed of a racing camel over a certain distance and conformation and production characteristics. The measurement can be expressed as a product of both genetic value of the camel and influence of environmental factors, thus P=G+E.

In other words, camels have different phenotypes because of the two factors; valuable genotypes and exposure to different environments during development. Some of the differences in environment to which camels are exposed can be: different nutrition regimens, climate, training and housing systems and disease control measures. Some differences cannot be specified such as errors of observation. It is possible by means of suitable statistical methods to obtain quantitative estimates of these several sources of variance. Estimates can also be obtained by using records on relatives. Estimates of the proportion of the phenotypic differences, that are genetic, are important to the camel breeder (Shereif and Tinson, 2000).

Q. Write notes on the following selection parameters:

a) Genetic variation, b) Standard deviation, c) Heritability and d) Response to selection.

a) Genetic Variation: Selection can be effective only when the population contains genetically variable individuals. Some traits have little genetic variation and others express considerable genetic variation. The information concerning variation in different traits of camels is greatly lacking. However, based on information from other domesticated animal species, it is likely that there is little genetic variation in fitness traits e.g. fertility.

b) Standard Deviation: This measure is important to identify a superior camel for a quantitative trait. The standard deviation is the square root of the phenotypic variation and describes the phenotypic variation of a trait about the average for this trait. In a normal population, 68% of all the values should fall in the range of the average ± 1 standard deviation. About 95% of all individuals are included in the range of the average ± 2 standard deviation. A camel would be superior to 95% of the general population if its value for the trait was greater than the value of average ± standard deviation. If a smaller value of a trait is desired, the camel's value would be less than the average ± 2 standard deviation. In a breeding programme for a certain trait, the intensity of selection (i) can be calculated for the desired selection differential (s) from the knowledge of standard deviation (σp) using the following formula:

$$i = S/\sigma p$$

The selection differential refers to the superiority or inferiority of those individuals selected for parents (P_s) as compared to the average of the population ($\bar{P}$) from which the breeding animals were selected. Selection differential may be noted by the following: $S = (P_s - \bar{P})$.

Intensity of selection can have an important effect on genetic progress, particularly in the selection of male camels since fewer males than females are needed under conventional breeding programme.

c) Heritability: Each camel has a genetic limit for each trait and this limit is set at conception. Rarely does an individual reach its genetic potential since environmental factors influence the trait. To eliminate these environmental factors, heritability estimates have been calculated for many quantitative traits in various species. Heritability estimates refer to the portion of the phenotypic variance in a population that is due to heredity and expressed in percentages.

To estimate the heritability, different methods are used such as intrasire regression of offspring on dam, offspring-parent regression and sib analysis, including full-sib and half-sib. Probably, except a few no heritability estimates are available for traits of economic importance in camels. The heritability for height at withers is high (84%), showing that only 16% of the variability is caused by environmental influences. Therefore, a high heritability estimate is an indication to the breeder that considerable genetic progress can be made in improving the trait when selection is based on the individual's own phenotype. High heritability also indicates that additive gene action is more important for that trait and the mating of the best to the best should produce more desirable offspring. A low heritability estimate indicates that there is low correlation

between genotype and phenotype. Therefore more attention should be paid to environmental influences since a breeding programme aimed at improving the trait may not yield the required results.

d) Response to Selection: A thorough knowledge of the selection parameters enables you to predict the genetic progress in one generation for any desired trait in the camel. In nature camels have undergone the process of selection whereby survival and reproductive success are the main components. It also implies that if a particular characteristic in the camel is favoured in a given environment, the genes giving rise to it survive the selection process and are passed onto the next generation. In this way favoured alleles increase in frequency at the expense of less desirable alleles and the genetic constitution of the population changes and evolves (Shereif and Tinson, 2000).

Q. Discuss the selection of camels with superior genotypes.

Organized selection is being practised more in racing camels than any other type of camels. In racing camels selection practices have been based on identifying and mating the best to the best. Better results are obtained when both the parents have excellent racing records and that racing ability has a high heritability. Since selection in such matings is largely based on environmental influences rather than the true breeding value of the camel, therefore in many cases the outcome is disappointing. In order to identify camels with superior genotypes, it is important to minimize environmental influences by examining accurate performance records. These records include the record of the concerned animal, performance record of the progeny, and closely related relatives. The order of importance of these records varies according to the heritability of the trait. To adjust performance records to a common base, information is also needed regarding environmental factors that may affect the chance of winning such as age, nutrition, skill of the trainer, sex, health, starting position, level of competition and the condition of the racing track. Unlike race horses, adjustments for these factors have not been made in racing camels. Therefore, biases are expected from the use of unadjusted records, resulting into slow rate of progress.

The essential trait for racing camels is speed over a certain distance. Conformation and temperament are important to the extent that they influence racing ability, but racing ability is a composite measure of all such factors. There are fast camels of varying conformation and temperament, which implies that no hard and fast standard for conformation and temperament has been framed. It may be said that camels can have good conformation and temperament without good performance, but cannot have good performance without good conformation.

Q. What may be the implications of inbreeding in racing camels?

Most breeding programmes in racing camels involve the use of a limited number of champion parents to produce the progeny. The obvious outcome of such matings is the increase in homozygosity through inbreeding. When inbreeding is accompanied by selection, individuals that are homozygous for desired traits are selected and used as breeding animals. Subsequently they pass their desirable genes to the next generation. Inbreeding has the disadvantage that it uncovers undesirable recessive genes that are expressed phenotypically in many forms such as genetic defects, small sized animals,

reduction in fertility and vigour. It is therefore suggested that in using the present system of inbreeding in racing camels, a large proportion of the less desirable individuals in the population needs to be regularly culled. This certainly requires that a large number of camels be produced which may prove to be very expensive.

Q. Name and discuss new breeding and genetic developments in camels.

Identification System: Microchip identification is widely used in several countries in cattle, horses, domestic pets, etc. The chips are implanted in the nuchal ligament in the neck when the calves are 4 to 6 weeks old. This system provides permanent identification. A computer programme can be developed to retrieve information specific to every camel including parents, farm location, trainer, racing history, treatment, vaccination etc. Accurate identification is particularly important in the camel embryo transfer (ET) technology. Firstly, it is occasionally possible for an ET camel calf to have up to three mothers (genetic, surrogate and foster). Secondly, it can take up to 3 years before assessment of good racing ability can be made with camels often moving locations between trainers. When superior offspring are identified, it is then possible to reuse their respective parents as donors in future ET programmes.

Multiple Ovulation Embryo Transfer: This technology is a method of rapid genetic improvement by increasing the selection intensity of both parents. The same has been applied to dairy cattle, sheep and goats. In camels the technique is being used since 1989 in the ET unit at Al-Ain, United Arab Emirates (Shereif and Tinson, 2000). Ultrasonography is necessary to follow the complex follicular waves in order to optimize the embryo production and collection. It is not only applied for racing ability but also can be used for any trait of economic interest in camels.

Important Advantages of Embryo Transfer: Under normal breeding management because of long gestation period (about 13 months), one female produces a calf every two years. It often takes 3 to 4 years before the performance of the offspring is assessed. Some of the best females can continue to race up to the age of 15 to 16 years before their genes are passed to the next generation. Female camels are generally faster than males, thus are more sought after for the production of offspring. ET facilitates rapid selection for the top females. On the other hand, AI is normally used to increase the selection intensity of male parents. Moreover, there is evidence from other domesticated animals that the response to selection is grater using ET as compared to AI. For example by using ET in dairy cattle, a genetic improvement in milk production was found to be 30% above that obtained by AI. ET facilitates progeny test of many bulls using the same female for each bull concomitantly and thereby minimizes the environmental influence and increases the speed and efficiency of estimating the true breeding value of each bull. The top racing camels purchased by wealthy Sheikhs of Middle East can fetch prices as high as one million US dollars or even more.

Frozen Embryo Storage and *In Vitro* Fertilization (IVF): The first pregnancy from frozen embryo transfer was achieved in 1991, whereas the first birth from a camel embryo previously stored at -96°C in liquid nitrogen did not occur till February 1995 (Shereif and Tinson, 2000). The technique, however, still needs more improvement.

Collecting mature ovum directly from the follicles before they are released and then fertilization with the sperm is done under controlled laboratory conditions. IVF offers the possibilities of breeding camels with reproductive pathological conditions such as ovarian/bursal fluid syndrome where neither normal breeding nor embryo collection is possible. It is also anticipated that the collection of oocytes directly from the follicle would facilitate possible mixing with sexed sperm using flow cytometry sperm selection and intra-cytoplasmic sperm injection to increase the percentage of females produced. IVF technology is also necessary for any future gene transfer project in camels. Molecularly cloned DNA can be introduced into freshly fertilized egg, whether the cloned DNA is for increased quality/quantity of milk production, disease resistance, or for a factor yet to be identified associated with speed (Shereif and Tinson, 2000).

Recombinant DNA Technology: Recent advances in molecular techniques opened a new era with a wide range of application in animal and plant breeding, medicine, forensic science, evolution etc. The recombinant DNA technology has been applied to numerous organisms for different purposes. In camels, parentage was accurately resolved using human minisatellite probes 33.60 and 33.15 hybridized with camel DNA. Random Amplified Polymorphic DNA (RAPD) finger printing technique has been used to detect genetic variation in racing camels and to differentiate between strains of Trypanosoma including detection of mixed infection. Electrophoretic karyotyping and arbitrary primer-polymerase chain reaction (AP-PCR) has been used to study genotype and drug resistance phenotype *Trypanosoma evansi* in a population of camels. Recombinant DNA technology can also provide a useful tool for camel archeological studies.

Parentage and kinship identification are particularly important in the pedigree analysis and pedigree programmes. Work in this field on racing camels using short tandem repeat (STR) polymorphic markers is already in progress. Such work requires development of a range of highly heterozygous STR loci in camels facilitating parentage identification with a very high accuracy (>99%). STR alternatively known as microsatellite loci, are regions of DNA composed of short (1-6 bp) sequences repeated in tandem. Now minisatellites have been replaced by microscatellites as a method of choice in parentage identification of Eukaryotic organisms. Microsatellite analysis relies on PCR rather than on Southern blotting and hybridization procedures employed in minisatellite analysis. It is faster and requires much less DNA. It has been suggested that camelids, in general, represent the most extreme case of chromosomal conservatism among mammals. Studies of polymorphism in the old world camels also showed little or no genetic variation of blood proteins. Based on several studies, a general agreement emerged that DNA techniques should be exploited more often in future on camel breeding, parentage verification, population differences, disease control and archeological studies.

Transgenic methods are best demonstrated in the mouse, but these can also be used in camels to produce better animals. The nutritional value of milk can be enhanced by increasing the ability of the camel's mammary gland cell to secrete casein. Another possibility is to develop transgenic camels that can resist viral disease by modifying their genes to produce viral glycoprotein. Camels can also be bred to increase their production of the antiviral substance interferon.

Researching mitochondrial DNA (mt DNA) in camels can also provide valuable information. Animal mtDNA is maternally inherited, and therefore, it facilitates a unique way of identification by comparing sample results with those of even distant relatives. During fertilization only about 1% of the mitochondria are contributed by the sperm. Thus an individual's mother, sibling and all maternal relatives contain almost identical copies of mtDNA. Although mtDNA represents less than 1% of total cellular DNA, however, it exists in a high copy number. Mammalian cells typically have several hundred mitochondria, each containing several copies of mt DNA for a total of approximately 1000 to 10000 copies per cell. The special characteristics of mt DNA makes it a valuable tool for species identification, population studies and evolution.

A DNA project needs to be designed to map the camel genome. This project would generate databank of genetic information that could be used to improve camels for disease resistance, milk production, racing ability, and any other desirable trait in much less time with a greater efficiency. Researching the camel genome should be a major project requiring substantial amount of funds, qualified work force and collaboration with relevant scientific institutions. The availability of data from human, mouse and other mammalian genomes will greatly facilitate the identification of the counterparts in the camel (Shereif and Tinson, 2000).

Q. What possible effects are expected due to reversal of the process of natural selection?

In this regard two models have been proposed. First, the homeostatic model, in which heterozygous individuals at the loci affecting the trait are assumed to have higher fitness. For this model, individuals around the population mean are likely to be more heterozygous. Fitness of individuals would be at the maximum at the mean phenotypic value of the trait and would decline as it departs from that value. The second model is the optimum mode, which relates fitness directly to the phenotype of the trait, irrespective of the underlying genotype. Both models imply that individuals with intermediate values for a particular quantitative trait have the highest fitness. Thus any shift in the mean of the trait would be expected to result in a reduction in fitness components such as reproductive efficiency, differential mortality at immature stage, viability, competitive ability, sterility etc. Thus basic principle of natural selection should be duly considered whenever directional selection is attempted for a quantitative trait.

It is noteworthy that while natural selection allowed the camel to evolve incredible physiological adaptations to desert, there may have been in the process a negative selection for reproductive efficiency. The high incidence of embryonic death and abortion, coupled with long gestation length and high intercalving interval would appear to support this theory. In range bred camels the yearly calving rates were as low as 40% and neonatal to yearling death rates on an average 30%. The breeding seasonality of the male and his 'difficulty' in mating unaided also contribute to inefficient breeding. It could be stated that it was a necessary 'negative selection' to ensure the population survival in an environment where feed and water resources are scarce. Modern artificial breeding techniques and application of genetic principles can reverse this inefficiency and optimize the available individual's potential. With ET technology calving rates per

individual can be enhanced to 300% and calf mortality rates in properly managed herds can be reduced to less than 10%.

Q. Write a brief note on congenital defects in camel.

Because of slow reproductive rate and slow herd growth, many aspects of the camel are yet to be studied in detail. A few examples of congenital defects are ectopia cordis (a closure defect of the ventral body wall during foetus devlopment), parrot mouth (in this condition the mandibula is shorter than the maxilla; affected animal may have grazing problem), short digit (in this condition the animal has shortened digital bone(s) leading to impaired walking and idiopathic alopecia (almost complete baldness). These conditions occur rarely and thus considered of little economic importance. Camel pastoralists do not use such animals for breeding if they survive to maturity.

Q. Is ultrasonography of the genital tract of camels a useful technique?

As a technique of choice for examination of genital tract, ultrasonography has gained a wide acceptance in several countries. Its application in female theriogenology ranges from the determination of physiological status, ovarian activity and pregnancy diagnosis to the detection and diagnosis of the genital tract diseases. Ultrasonography of the male helps in the evaluation of the testicular tissue, testicular envelopes and epididymus as well as the pelvic organs. Determination of ultrasonographic characteristics of the ovarian structure and uterus and their relationship to each other, at different stages of the cycle, has led to more efficient management of reproduction in several species. Similarly, in camelidae, the technique has proved to be a valuable tool for research on follicular dynamics and is becoming popular for early pregnancy diagnosis and management of breeding both in the dromedary and Bactrian. Even in some developing countries, the field use of this technique has become possible.

Q. Discuss briefly the principle involved in the technique of ultrasonography.

It is an imaging technique reflecting the degree of propagation or reflection of a beam of ultrasound applied to layers of animal tissue. The transducer or probe of the ultrasound has both the emitting and receiving properties for ultrasound waves. The beam of ultrasound is sent directly over the area being investigated. These sound waves propagate at different rates depending on the density of the tissue being examined. When the tissue has a minimum density, a proportion of the ultrasound wave is reflected back and is received by the transducers. It is then converted to electrical impulse signal that is displayed as a grey-scale image on the screen. The intensity of grey in the image increases as the amount of echo received increases and the image becomes totally white on the grey-scale when a large proportion of ultrasound waves emitted are reflected back. The general description of an ultrasonogram starts by describing the echotexture of the image (homogeneous or heterogeneous echotexture) and then the intensity of the echo (anechoic, hypoechoic or hyperechoic). In the case of heterogeneous echotexture, all areas should be described in relation to their anatomical position such as the main organ investigated and the degree of their echogenicity (Tibary and Anouassi, 2000).

Equipment: The equipment used is different from one application to another. However, high end equipment is usually suitable for many applications if fitted with an appropriate transducer. A multipurpose ultrasound machine should allow use of both M (motion) and

B (brightness) real mode ultrasonography as well as a choice of linear and array probes. The frequency of the ultrasound waves produced is an important criterion of choice for the transducer. The most common frequencies used in animal practice are 3.5, 5 and 7.5 MHz (Megahertz). The difference between these sound wave frequencies resides in the penetration, distance and the detail of the image obtained. Low (3.5) frequency sound waves travel farther than high frequency waves (7.5 MHz), but produce a low resolution image. Another difference in transducers is the arrangement of the elements or piezoelectric crystals responsible for the conversion of electrical energy into ultrasound and vice-versa.

Two types of arrangement are available: linear or sector. In the linear array transducers, the elements are arranged side by side along the length of the transducer. These send and receive the ultrasound in a linear fashion allowing visualization of the structure in a rectangular plan with a width corresponding to the size of the probe and a length corresponding to the penetration rate of the waves. The sector scanners have a narrow arrangement of the elements and send a focal beam that spreads over an angle and produce a pie shaped field of examination. This type of transducer is used if the area to be examined lies just under hyperechoic structure. These probes (transducers) are generally used to investigate organs within the rib cage so that the ultrasound beam is sent through the intercostal space avoiding the ribs. For gynecological use, the ultrasound machine should operate on a B-mode with at least a 5 MHz linear probe and preferably a second 3.5 MHz. The 5 MHz allow visualization of follicles as small as 2 mm in diameter and enable the operator to distinguish between very subtle degrees of echogenicity. The 3.5 MHz tranducers are used for the examination of deep structure (foetus in advanced pregnancy). M-mode ultrasonography is used in some instances to evaluate the heart function of the foetus. The most recent technical development in the gynecological ultrasonography is the introduction of special vaginal transducers for aspiration of follicles and should be considered in research laboratories dealing with *in vitro* fertilization.

Q. What type of ultrasound scanner should be purchased for large animal practice?

There are several types of ultrasound scanners available in the market. The following is a summarized list of the most important questions that should be addressed when deciding ‘which is the best machine’? i) What would be the main use of the machine,? ii) What is the volume of work for its use? iii) What is the degree of familiarity with the machine? iv) Is there a technical support available nearby? v) What is the reliability of the equipment and the manufacturer? vi) What is the comparative price of the equipment?

One critical factor to consider when purchasing any such equipment is the availability of technical help and the ability to service the machine within a reasonable time frame (Figure 16). Acquire an ultrasound machine from a reputable, internationally known firm and directly from an exclusive agent. The price of the machine should be weighed adequately against the reputation of the equipment and availability of technical support.

Q. Discuss the examination technique and preparation of the camel for ultrasonography of the genital organs per-rectum.

Ultrasonography of the genital tract is done per-rectum or per-vagina in the female. External abdominal ultrasonography is not done in camels because of the lack of penetration. In practice, examination per-rectum is the most widely used technique. Vaginal ultrasonography is used in research for echoguided follicular aspiration or aspiration of uterine cysts and embryos or injection of embryos and intrafollicular injection. In the male, ultrasonography is used externally for the examination of the scrotum and its contents. It is used per-rectum for the evaluation of the pelvic organs.

Preparation of the Animal: The preparation is identical to that required for routine rectal palpation. Most of the camels can be palpated in a standing position if stocks are available (Figure 17). Reluctant or agitated animals should be tranquillized by intravenous injection of 0.2 to 0.3 mg/kg of 2% Xylazine. This causes immobilization of the animal and relaxation of the anal sphincter, making manipulation very easy. Sedation and examination of the animal should be done as soon as possible because agitated camels quickly develop a profuse diarrhoea (due to hypermotility of the intestines), which makes palpation and ultrasonography difficult. Clean the rectum of faecal material by scooping out faecal balls with a lubricated hand. Usually, the dilation of the anal sphincter causes a reflex defaecation that should be allowed to progress naturally by removing the hand. After emptying of the rectum, the genital tract is palpated completely, starting with the cervix. The cervix is identified by placing the hand flat on the floor of the pelvis in continuation with the uterine body. It is not easily grasped in the hand as in buffalo or cattle. The uterus and its horns are identified just cranial to the cervix and can be within the pelvic cavity (young females) or slightly in front of pelvic brim (old or pregnant females). The uterine horns are easy to identify in animals with a mature follicle because the uterus is contracted and the horns are straight. The uterine tube is usually felt as a tortuous band. The ovaries are palpated laterally and caudally to the ipsilateral horn. They are usually elliptical and very irregular especially in older animals due to the presence of many old corpora albicantia. They measure 3x2x1.5 cm. Corpora lutea are easily identified as well protruding structures measuring 16 to 25 mm with a liver like consistency.

It is mandatory to evaluate the animal first by palpation per-rectum before ultrasound examination. It allows the practitioner to determine the general position of the genital organs so that the ultrasound probe can be positioned properly. The probe is introduced in the rectum taking care to provide ample lubrication. The probe is always maintained within the hand of the operator with crystals facing ventrally. Different parts of the genital tract are examined in the following order: the cervix, body of the uterus, then each uterine horn followed by the ipsilateral uterine tube and ovarian bursa. Thorough examination requires that the probe be in very close contact with the mucosa so that the image is very clean. The probe should be moved very slowly along different parts of the genital tract. In order to have a good contact with rectal mucosa, the probe should be dipped in a coupling gel or in a lubricant before insertion in the rectum.

Ultrasonography Per-Vagina: It is used mainly for retrieval of oocytes from growing follicles and a special 30 to 40 cm long probe fitted with a sector transducer is used. The animal should be sedated because most female camels are reluctant to vaginal

manipulation. The probe is inserted into the vagina and advanced gently until it comes in close contact with the fornix. The genital tract is manipulated per-rectum so that the ovary is presented to ultrasonographic field and the follicles are identified. Each follicle can then be aspirated by inserting a single or double bore long needle from the base of the probe and guiding it in the special canal of the probe until it becomes visible on ultrasonogram when it comes out at the transducer end. The follicle is stabbed and aspirated using a suction pump hooked to the needle and set at a predetermined negative pressure. If a double bore needle is used, the second needle can be used simultaneously for suction and flushing the content of the follicle.

Ovulation: In camels, ovulation takes place between 24 and 48 hours after mating. Detection of ovulation by ultrasonography is very difficult unless the female is monitored very closely. Ovulation is usually suspected when the dominant follicle disappears following breeding or treatment with hCG or GnRH.

Evaluation of Superovulation Treatment: In recent years, one of the major uses of ultrasonography in camels is the evaluation of superovulation treatment and management of breeding in donors and the planning for recipients preparation. In well equipped laboratories, ultrasonography is used to examine the ovaries of superovulated females on alternate days. The first appearance of a follicular wave induced by treatment with PMSG (eCG, 2500 to 3000IU) or FSH (35 to 45 mg given in decreasing doses over 4 days) takes place 3 to 5 days after initiation of treatment. Most of the superovulated females show mature follicles between 6 and 8 days following the beginning of the treatment. The stimulatory response of these treatments is variable from zero to a multitude of follicles. In some cases the number of follicles is so high that it becomes impossible to have an accurate count. This situation is of great importance because it is usually linked to a failure of ovulation or results in many corpora lutea but no embryo at collection. Ultrasonographic monitoring of superovulated animals is a good tool to study the causes of ovulation or failure of fertilization (Tibary and Anouassi, 2000).

Q. Discuss the use of ultrasonography in early pregnancy diagnosis and evaluation of the growth and viability of foetus.

Early pregnancy diagnosis and evaluation of the foetus are the most common uses of ultrasonography in the female camelids. This technique has been used successfully in dromedary and bacterian camels. Pregnancy diagnosis in llamas and alpacas can be done using abdominal ultrasonography, however, this technique can be applied in animals pregnant for more than 3 months. Pregnancy diagnosis is possible in camelids as early as 15 days postmating. This diagnosis is based on two main criteria: i) visualization of an embryonic vesicle, and ii) visualization and maintenance of a corpus luteum of pregnancy. For early diagnosis of pregnancy by ultrasonography requires that the uterus should be investigated all along its length and finding should be compared to the ovarian situation. Visualization of a functional corpus luteum in one of the ovaries is a must in order to confirm pregnancy status.

Visualization of the Early Embryo: The embryonic vesicle in camelids is relatively difficult to visualize in early pregnancy because it is very elongated, the embryonic fluid

is dispersed and the uterus is relaxed. In the early stage (14 to 16 days postmating), the embryonic vesicle appears as a cross-section of the uterine horn like a star shaped anechoic area. Diagnosis is best made by visualizing the vesicle at the tip of the horn where it is likely to have most of the accumulated embryonic fluid. The vesicle is almost always present in the left uterine horn. The best results are obtained at this stage with 5 MHz transducer. As pregnancy advances, the embryonic vesicle increases in size and is better visualized. It is round in cross-section and oblong in longitudinal view of the uterus. At 18 days of pregnancy, diagnosis of embryonic vesicle should not pose any problem for an experienced examiner.

The embryo becomes visible within the embryonic vesicle around day 20 postmating. The embryonic mass continues to grow and the foetal heart beats are evident between day 22 to 25 of pregnancy. The foetus becomes separated from the uterine wall by day 35 and the amnion becomes visible as a thin echogenic film above the foetus. The amniotic fluid is slightly more echoic than the allantoic fluid. All parts of the foetus and its envelops are easily identifiable by day 50 postmating. At 3 months postmating and beyond, visualization of the foetus becomes rather difficult because of the increased size of the pregnant horn especially if a 5 MHz transducer is used. The development of the foetus beyond this stage is appreciated better with a 3.5 MHz sector transducer.

Visualization of Pregnancy Corpus Luteum: The corpus luteum is the major source of progesterone during pregnancy in camelids and its presence is required throughout the gestation period. Thus visualization of the corpus luteum adds to the accuracy of the early pregnancy diagnosis. All pregnant animals should have at least one functional corpus luteum. In the dromedary, the minimum size found of a single corpus luteum of pregnancy is 18 mm. The presence of 2 and up to 4 corpora lutea during pregnancy has been reported in camelids. Multiple corpora lutea can be smaller in size. It is almost impossible (or difficult) to visualize the corpus luteum beyond 3 months of pregnancy because the ovary then is beyond reach.

Q. What usually is the degree of accuracy of early pregnancy diagnosis using ultrasonography?

The accuracy of early pregnancy diagnosis using ultrasonography is very high. However, from a management view point, it is important to differentiate between a pregnancy diagnosis results and delivery and accuracy. It is important to remember that accurate early pregnancy diagnosis does not guarantee a birth about 13 months later. Pregnancy diagnosis should be confirmed at later stages because of the high level of embryonic loss in first 2 months of pregnancy.

Q. Write short notes on determination of gestation stage, diagnosis of foetal viability and determination of foetal sex by ultrasonography.

Determination of Gestation: It is important in management in order to have a predetermined parturition date. You may be asked to determine approximately the stage of gestation especially in case of misbreeding or group breeding. Age of the foetus can be determined by measuring some of its body parts. In many species this is done by measurement of the head or trunk diameter. In the camel, visualization of the foetus is possible only in first 4 months of pregnancy and measurements are difficult to make.

Determining Foetal Viability: Compared to other farm animals, camelids have very high incidence of embryonic loss. It is, therefore, important to determine the viability of the foetus at each pregnancy diagnosis attempt. The criteria used to determine the status of pregnancy include shape and growth of the embryonic vesicle, ethogenicity of embryonic fluids, cardiac activity of the foetus, growth of the foetus and finally its movement. In the early stages of pregnancy, the most used criteria are the shape of the embryonic vesicle and the echogenicity of its contents. The normal embryonic fluid is anechoic. It becomes slightly echoic or contains echogenic debris in case of embryonic death. Foetal heart beats are a good indicator of embryo viability at all these stages of pregnancy where the rib cage can be visualized without problem. Embryo mortality is suspected when there is no foetal heart beat, the embryonic fluid is echogenic and contains debris and there is evidence of a separation of the placenta from the uterine wall.

Determining the Foetal Sex: Ultrasonography has been used in determining foetal sex in equines and bovines between 60 and 100 days pregnancy. This diagnosis is based on the visualization of the scrotum, testis or udder and the relative position of the genital tubercle. Accuracy of this diagnosis depends greatly on the position of the foetus. In the camel, sexual differentiation is already completed by 50 days of pregnancy. However, there are some reports of unsuccessful attempts in determining sex of the foetus between 50 and 70 days of pregnancy (Tibary and Anouassi, 2000).

Q. Can ultrasonography be carried out of the reproductive tract of the male camel?

Ultrasonography is a valuable technique for the examination of the scrotum and its contents as well as the pelvic organs in the male. Examination of the pelvic organs in the dromedary is done with the animal restrained in the same manner as for palpation per-rectum in the female. Aggressive males should be sedated with Xylazine in order to reduce risk both to the animal and operator. After thorough evacuation of faecal material, the operator starts identifying parts of the internal genitalia per-rectum, such as the pelvic portion of the penis, the bulbourethral gland and the prostate and sometimes the ampullae of the efferent duct. Ultrasonography of these organs is best accomplished with a 5 MHz transducer (Figure 18).

For examination of the scrotum and testes, the scrotal area is cleaned of dirt and dry faeces to avoid interference in ultrasound. The testes are immobilized by gentle downward traction. The transducer is placed directly on the scrotal skin oriented according to the axis to be examined. Each testicle is examined following a transverse view by placing the tranducer perpendicularly to its long axis by moving it slowly from the dorsal to the ventral part. A round image corresponding to a slice of tissue is produced. Then the transducer is placed vertically parallel to the long axis of the testis to obtain a longitudinal view of the testicular parenchyma. Finally, the testicular cord is examined by placing the transducer in such a way that the image obtained corresponds to a transverse view of the tissue. Ultrasonography also provides a good means for precise measurement of testicular size.

The normal testicular tissue has two zones with different echogenicity. The periphery corresponding to the testicular parenchyma is homogeneous with medium density that

tends to increase with age. The central area is more echogeneous and corresponds to the rete testis. Particular attention should be given to the presence of pockets of fluids or more echogeneous area that can represent cystic dilation or presence of fibrosis, respectively. Presence of large quantity of fluid between the testis and its envelops has been observed in some males suffering from hydrocele.

For more detailed account of ultrasonography of the reproductive tract of the dromedary, you are referred to Tibary and Anouassi (2000) In: Selected Topics on Camelids (Gahlot: Editor). Answers to questions pertaining to this aspect have mainly been derived from the same source.

Q. Discuss pregnancy diagnosis from a different angle than discussed using ultrasonography.

For using any indirect method of pregnancy diagnosis, the camel will almost certainly have to be restrained in a sitting position to obtain a blood or urine sample and to make a rectal exploration for pregnancy diagnosis. Clinical method of rectal palpation is recommended for pregnancy diagnosis in the camel. The technique of palpation of the genital organs is the same as for the buffalo or cow, but the following features need to be kept in view in case of the camel: a) large corpora lutea are only present during pregnancy, b) 99% pregnancies are in the left uterine horn, c) the empty right horn is congenitally shorter than the left, and d) the amount of foetal fluid at all stages is less than in the cow. The presence of a CL in one or both ovaries is a very strong indication of pregnancy.

The palpable swelling of the pregnant (left) uterine horn in the dromedary cannot be detected before week 8, when the whole of the left horn is enlarged. At this time, both ovaries (one or both with CL) together with the uterus, are within the pelvis. At the end of third month, the pregnant left horn is clearly larger. It is at the pelvic brim and its corresponding ovary is in the abdomen. At the fourth month, the uterus is just in front of the pelvic brim, but most of it can be felt. During the sixth month, the foetus can be felt. From the seventh month individual parts of the foetus such as its head and legs can be identified. External observation of the animal's right flank shows spontaneous foetal movements from the ninth month and the foetus can be ballotted externally from the tenth month. In the following months there is obvious abdominal enlargement and the camel is lethargic. There is greater enlargement of the udder, sacro-sciatic ligaments relax, vulva becomes swollen. Rectal palpation reveals the uterus projecting backwards, occupying the anterior two-thirds of the pelvis. The foetus can be ballotted from both the flanks.

The presence of follicle stimulating activity has been identified in the blood of camels pregnant with foetuses measuring 11 to 85 cm. It has been found that the cuboni test for the demonstration of estrogens in urine can be successfully applied in the camel, as in the mare. Well developed corpora lutea are known to be present only during pregnancy and because progesterone level of >1.0 ng/ml is reached only after fertile mating, therefore, blood or milk progesterone assays can be a valuable tool for diagnosis of pregnancy in the camel.

There is no record of freemartinism in the small number of twins born. The incidence of twin gestation is 14% and the twins are born in only 0.4% of all births.

Early pregnancy diagnosis is very important for the successful application of modern breeding technologies such as artificial insemination and embryo transfer. Significant structural changes in the reproductive tract of female animals even during pregnancy can be visualized by ultrasonic image detection and videoendoscopic monitoring. Videoendoscopic hysteroscopy during early pregnancy in the camel is an exciting tool for descriptive and investigative research purposes. It is a new method for observing the interior of the vagina, cervix and uterus in non pregnant large animal species and for monitoring foetal development and obtaining samples of foetal fluids and tissues for research investigations during pregnancy. The flexible videoendoscope utilizes a powerful xenon light source. It gives greatly improved brightness, depth of focus and colour reproduction compared to the conventional fibre-optic endoscope. The process of endoscopy is not recommended for routine pregnancy diagnosis since it involves some risk. Ultrasonography, on the other hand is a safe and accurate method for the diagnosis of important reproductive events including pregnancy diagnosis (Chaudhary, 2000).

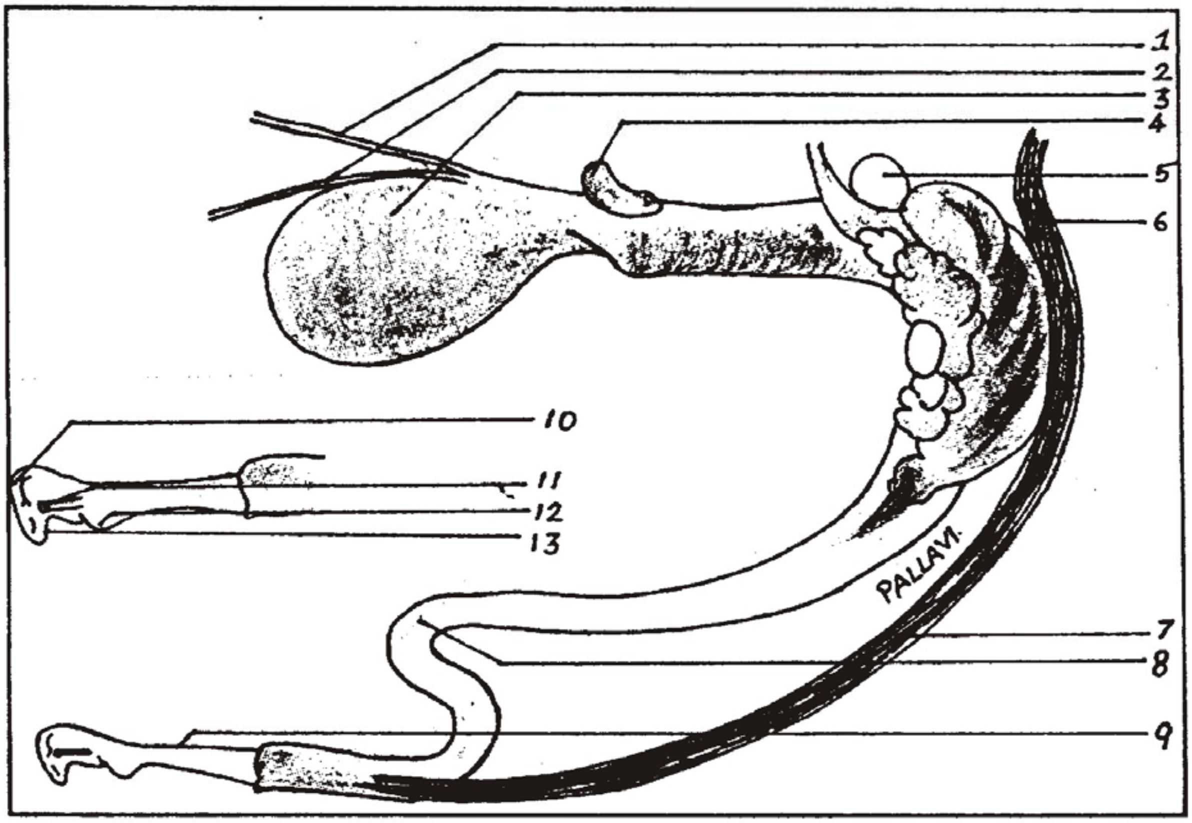

Fig. 10. Anatomy of the male genitalia

1. ureter, 2. ductus deferens, 3. urinary bladder,
4. prostate, 5. ischio-cavernosus muscle,
6. retractor penis muscles, 7. retractor penis,
8. sigmoid flexure, 9. tuberculum spongiosum,
10. urethral process, 11. mucus membrane fold,
12. terminal process, 13. free portion of the penis.

Source: Chaudhary (2000).

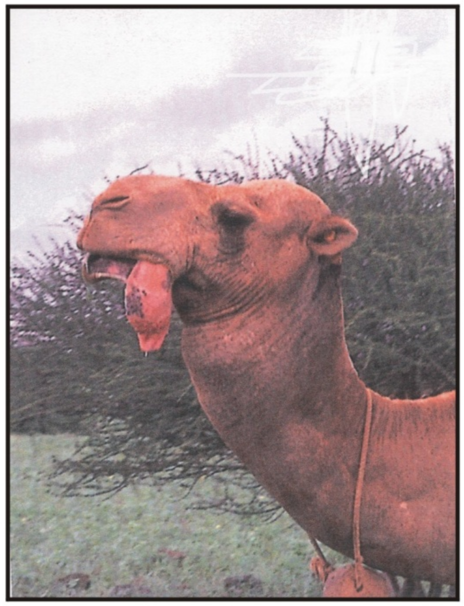

Fig. 11. Extrusion of the dulaa (soft palate) by a mature bull camel
Source: Schwartz and Dioli (1992).

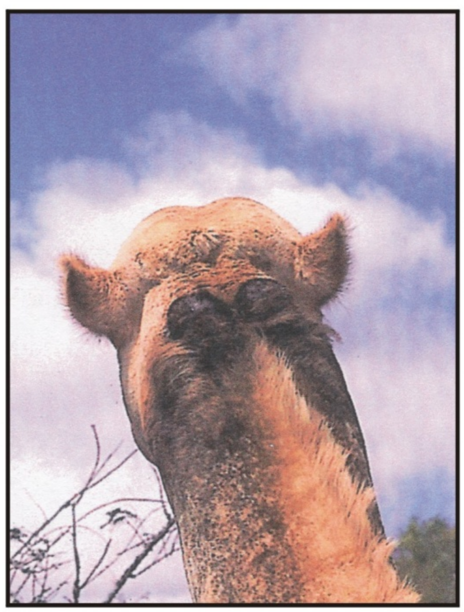

Fig. 12. Secreting occipital glands in a mature bull camel
Source: Schwartz and Dioli (1992).

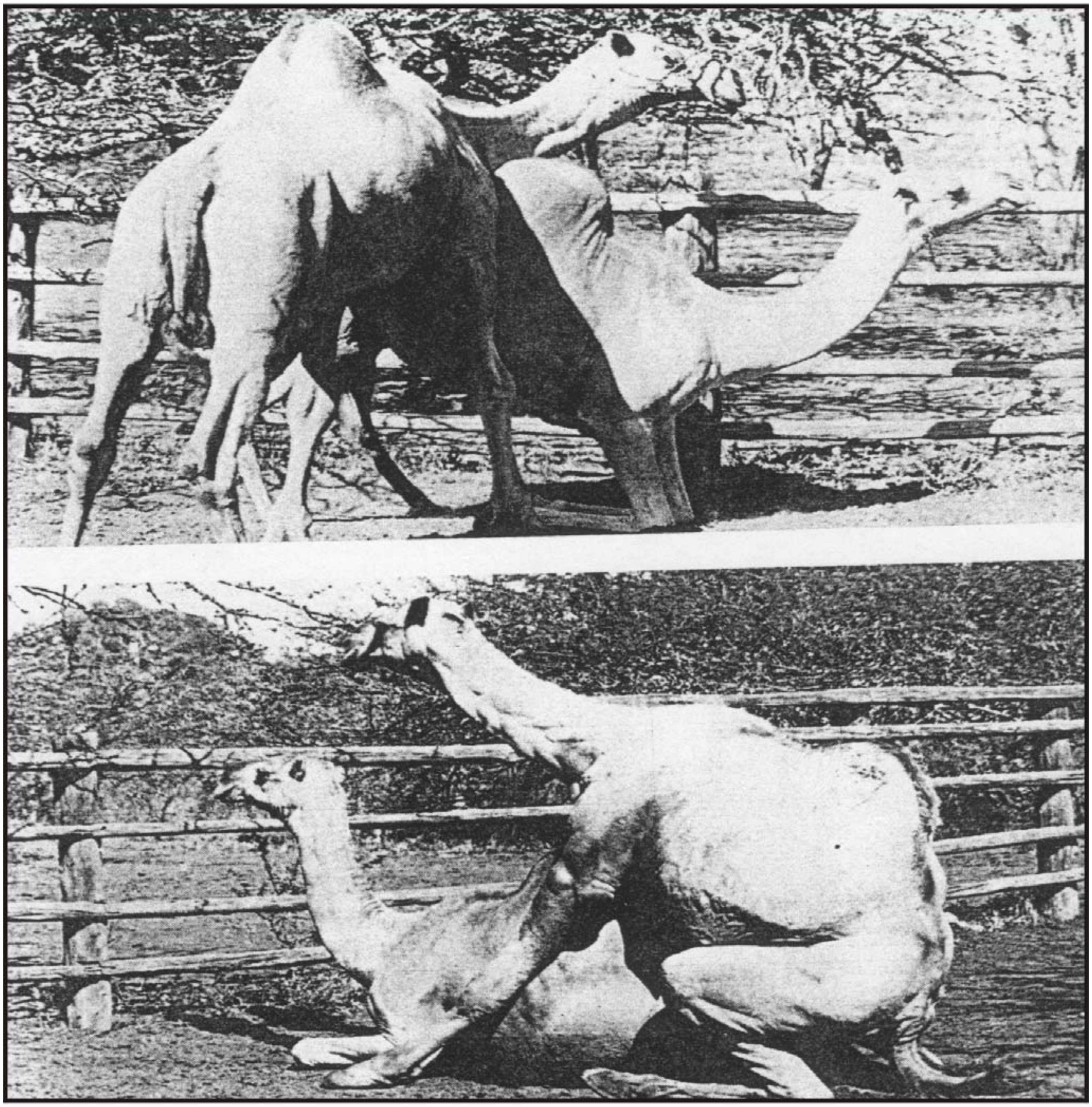

Fig. 13. Male camel forcing a female camel down (a above) and then copulating in the typical position for this species (b below) Source: Wilson (1998).

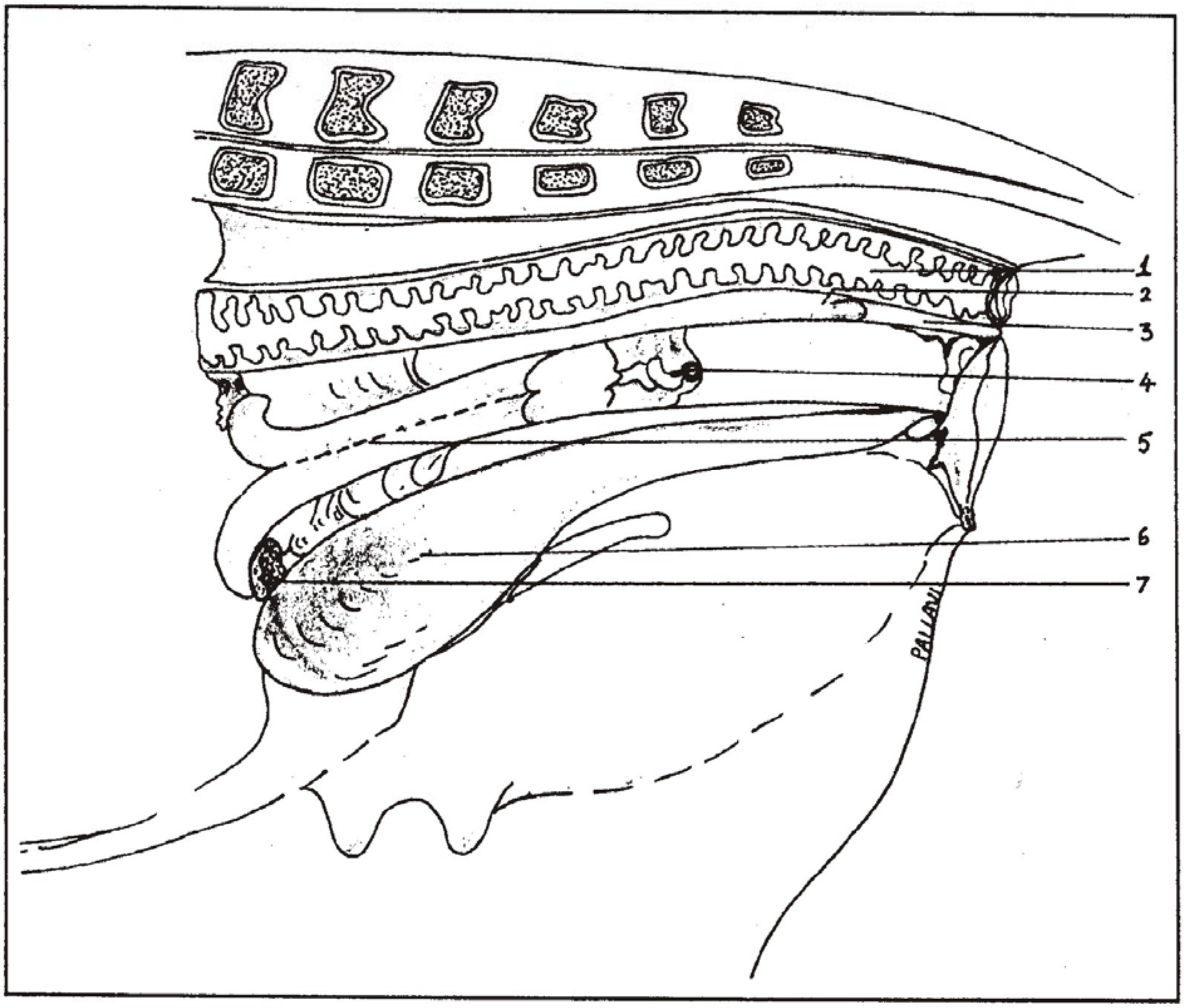

Fig. 14. Anatomy of the female camel genital tract

1. rectum, 2. rectogenital fold,
3. retroperitoneal space, 4. cervix,
5. uterus, 6. bladder, 7. left ovary

Source: Chaudhary (2000).

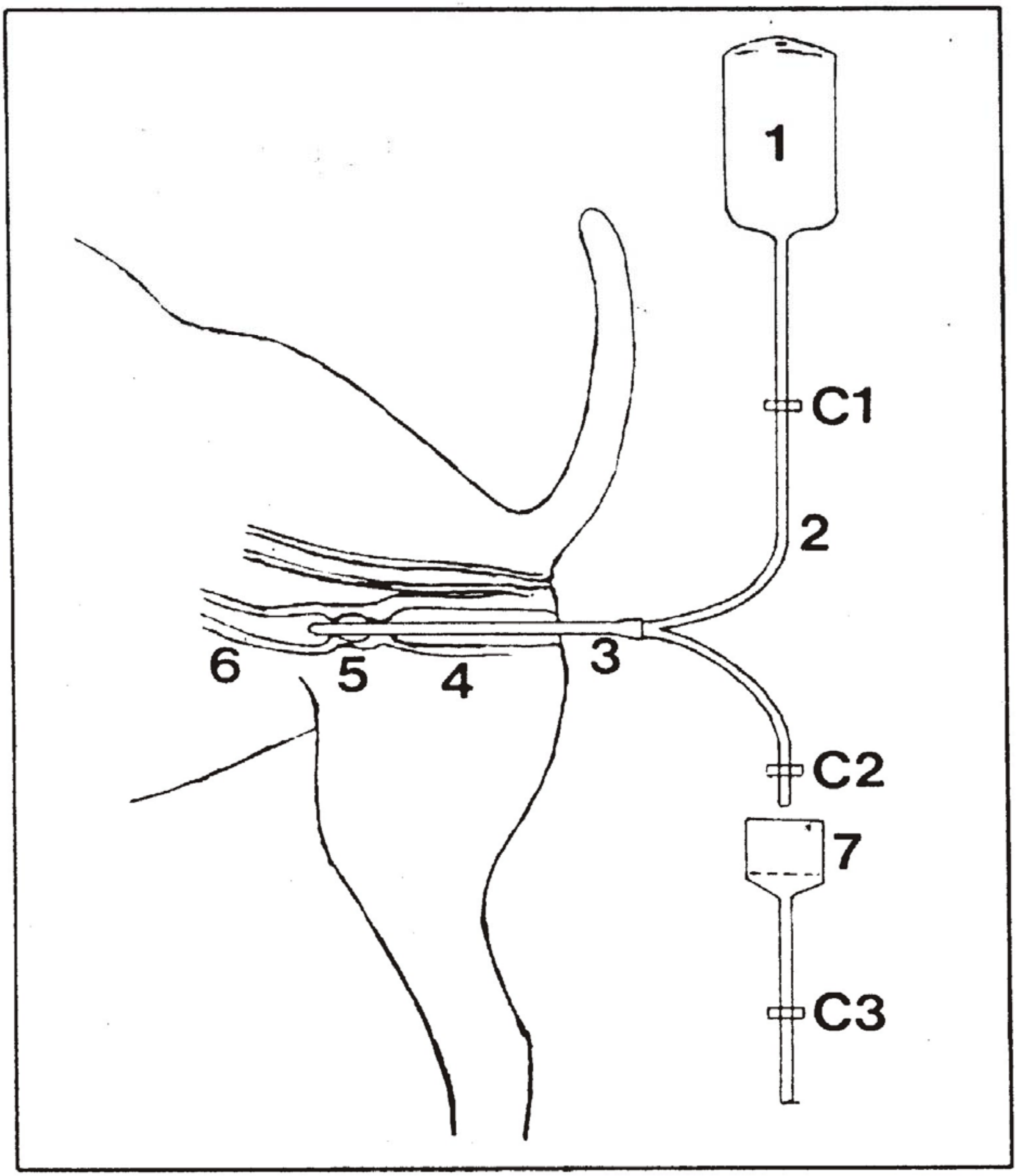

Fig. 15. Embryo flushing in the camel
1: flushing fluid; C1, C2, C3: tube blocking clips; 2: flushing tube set; 3: cuffed catheter; 4: vagina; 5: cervix with catheter inflated; 6: uterus; 7: embryo retaining filter
Source: Manefield and Tinson (1997).

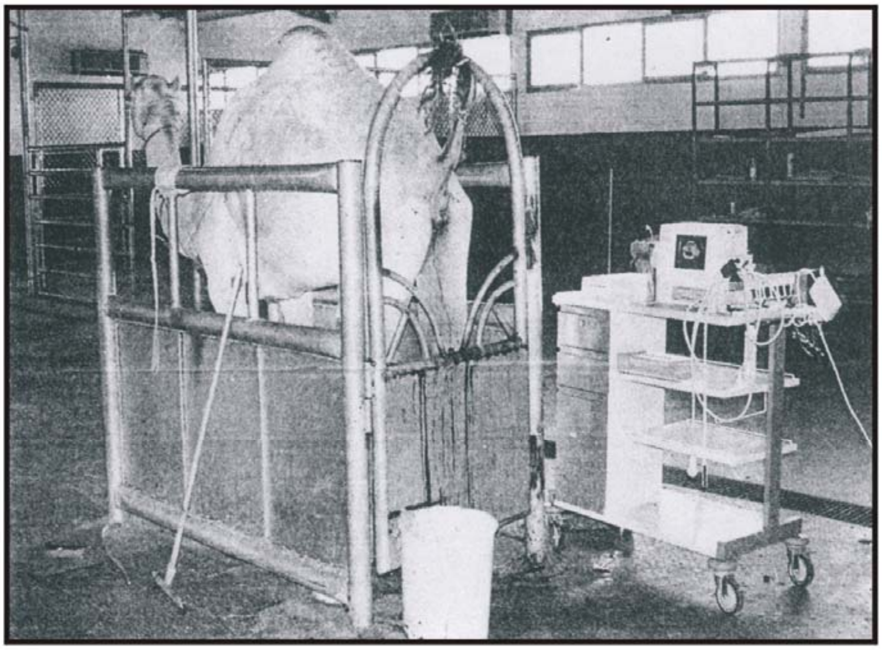

Fig. 17. Female dromedary placed in stocks for examination per-rectum
Source: Tibary and Anouassi (2000).

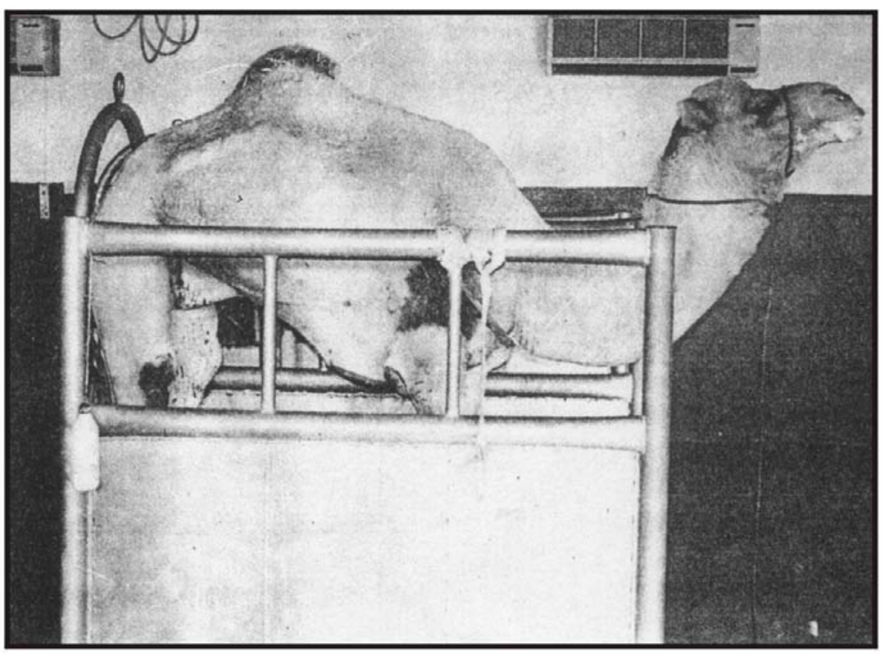

Fig. 18. Male dromedary restrained in a palpation chute for ultrasonography of testes
Source: Tibary and Anouassi (2000).

PRODUCTIVITY AND PERFORMANCE

Q. What does productivity denote?

Productivity of an animal can be defined as product output per animal unit per time unit i.e. litres of milk per buffalo and year or hectares ploughed per ox team per day. Productivity can also be defined as product output per unit input i.e. kg wool per man-hour of herding or kg liveweight gain per kg concentrate fed. Also productivity is defined as value of product output per unit input in monetary terms. Productive potential of an animal or a livestock species defines the biological limits, which may be of genetic, nutritional or physiological nature, within which productivity can be realized. Livestock management is the art to exploit the productive potential of an animal or a species to maximum productivity, which in term is not to be confused with maximum performance.

In its usual habitat, the hot and arid rangelands of Africa and Asia, the camel is a multipurpose animal. It produces milk, meat, leather, hair and wool and serves as riding, pack or draught animal. Productivity of a multipurpose animal is a composite value with many facets contributing. Exploitation of the productive potential for the various possible outputs will be a matter of producer preference, which in turn is influenced by natural, social and economic factors. If a racing camel can be sold for Rs. 60,000 and for much beyond that, there is probably no need to worry about milking its dam. However, if camel's milk is a subsistence staple, then it does not matter that a good milker is a slow runner.

Milk

Q. Give below a detailed account of milk production and composition and lactation length in *Camelus dromedarius*.

Camel milk is a valuable human food source in the semi-arid and arid environments of Africa and Asia. Total dry matter ranges from 12 to 15%, protein from 2.7 to 4.5%, fat from 2.9 to 5.2% and lactose up to 5.5%. Of special importance is the high content of vitamin C in areas where food of plant origin is rare, which may reach 2.9 to 3.6 mg/100 g. Estimates of milk yields differ widely. Reported daily yields range from 3.5 to over 20 litres, corresponding lactation yields range from 800 to over 4000 litres (Table 10). Likewise lactation lengths show a large variation of 8 months to almost 2 years. However, many of the higher yields quoted do not appear to be representative particular under pastoral production systems, where the largest proportion of camel's milk is produced.

Table 10. Summary of some reported milk yields (litres)

Source	Daily yields	Total yields
Bremaud (1969)	12	-
Dahl and Hjort (1976)	3.5-4.5	1890-2160
Ensminger (1973)	7.5	3300
Field (1979)	21	1887
Hartley (1979)	9	1800
Khan and Iqbal (2001)	11.66	4260/year
Knoess (1976)	10.4	2847
Lakosa and Shokin (1964)	8.1-19.0	4388
Leese (1927)	4.8	-
Leupold (1968)	6.7-10.0	2700-3600
Rosetti and Congiu (1955)	5	3105
Williamson and Payne (1979)	9	2722
Yasin and Wahid (1957)	9.1-14.1	1068-4118

Source: Modified from Schwartz and Dioli (1992).

Daily yields between 3 and 6 litres, with total yields between 1500 to 2500 litres produced within lactation periods of 15 to 18 months are most likely the common range of performance. Such yields do not sound very impressive when compared to milk yields obtained from buffaloes and cattle kept in intensive conditions. Considering the local feed base in semi-arid and arid areas, which is frequently inadequate to secure the mere survival of cattle, such yields are impressive. Beside the absolute quantity of milk produced it is the persistency of production, which is important for the subsistence of pastoral populations since it provides staple food throughout dry seasons and short drought periods, when milk production from cattle and goats has already ceased. It is in this context that production of camel milk assumes more importance.

There is now a continuous drift of nomads to urban centers. Because of this, mobile informal camel dairies consisting of 5 to 10 camels are often seen in the periurban areas of many medium sized and large towns of Pakistan. A large number of milch camels is always there around Karachi who daily provide milk for the milk shops. Women of camel herders each carrying about 15 litres of milk sell it to the city dwellers who use it for making milk products such as Yogurt and Khir. Camel milk mixed into buffalo and cow milk is daily sold at large consumption centers in Pakistan. Camel milk is now being marketed through a commercial dairy in Mauritania both as pasteurized milk and as cheese and some of these gourmet products are being exported to France. Full-scale commercial dairying has also developed in parts of Saudi Arabia and Libya. Camel milk accounts for more than half of the pastoralists nutrient intake during the growing seasons.

The composition of camel milk is similar to that of the goat but it contains more lactose and ash than cow milk and more ash than buffalo milk. Casein is lower in camel milk than that of the cow but whey protein is higher. Camel milk is usually bluish white in colour and may have a slightly salty taste and a very slightly acid or ‘sharp’ taste since

the pH is about 6.5. An odd thing about camel milk is its reduced content of total solids when produced by dehydrated animals or those under water stress. Total solids are usually in the region of 11 to 14% and fat 3 to 5%. Protein in camel milk varies from 2.7 to 5.4% while lactose is up to 5.5%. Mineral contents vary according to the type of feed eaten but usually there is a low calcium level while phosphorus levels are similar to that of other farm animals such as cow, goat etc. The amino acid make-up of camel milk is similar to that of other domestic species. Camel milk is a good source of vitamin C but contains little of carotene that can lead to the formation of vitamin A. The content of vitamins of the B complex is comparable to that of other milch farm animals. The camel milk is said to have medicinal uses as well because the vegetation used as feed by camels includes several herbs having potential medicinal value.

Q. Write a brief note on composition of colostrum of one-humped camel.

Early colostrum of camel is very low in fat (only 0.23%), but it becomes normal at about 10 days. There are also changes in other constituents over the same period. Protein, for example, is reduced from 13.0 to 4.0%, lactose rises from 2.7 to 5.1% and total solids fall from 20.5 to 14.7%. By tenth day fat content rises to about 2.7%.

Q. Generally what factors may affect milk yield in camels?

The factors affecting milk yields are those common to all dairy animals such as nutrient supply, health status, genetic potential for milk production, number of previous lactations or age of the animal and adequate water supply. The first three are readily exploitable for increasing milk production provided the respective inputs and services are available and their application is profitable.

Q. Is it possible to improve the genetic potential for enhanced milk yields in East African camels?

It is possible but only in very long term. Because of the low reproductive rate of camels, selection will be inefficient since virtually all fertile females will have to be bred and selection can be carried out in male breeding stock only. Crossbreeding with recognized high yielding dairy breeds of Asian origin is possible but has two main drawbacks. Firstly it would take 7 to 8 years before the first cross could be tested, secondly it is by no means ascertained that the improved genetic potential could be exploited in the pastoral systems in Eastern Africa. Feeding concentrates coupled with mineral supplementation and health care might help attain the goal. It is probable that good quality feed would be better used for dairy animals (buffaloes and cows) already bred for milk production. It, however, needs to be kept in view that many reported milk yields even for research stations, fail to take into account the milk taken by the camel calf.

Reports indicate that in Pakistan camels outyield Friesian x Sahiwal and Sahiwal cattle as well as buffalo under some conditions and that these higher yields compensate for lower fat content in camel milk. Yields as high as 5330 litres in 13 months have been obtained under station management at Al-Jouf in Saudi Arabia and 3900 litres in 305 days at Matar in Tunisia. However, it is likely that traditional owners will continue to breed camels that can produce milk for up to 18 or more months and may not want to lose this trait in exchange for high daily yields. These apparently low yields should be seen in relation to the needs of the owners, climate and feed conditions. As already mentioned,

sufficient milk is taken by the calf and is not recorded. Milking frequency also influences the apparent and probably the real yield since it varies from as little as once every 2 to 3 days to as often as six times a day.

Q. Give a detailed account of quality of the camel milk.

For as long as records concerning camel milk have been kept, the special properties of camel milk have been mentioned. It was because of these properties that caused man to take a milking camel with him to cross vast deserts. Apart from this, milk was available even under harsh conditions. The most special property of the camel milk is its water content. This, at first, does not seem to be a physiological reaction, because the quantity of milk produced by goats and cows, which face lack of drinking water, declines and the milk becomes concentrated i.e. saving of body water. However, if lactating mammals in the cold provide their young with large amounts of fat in their milk to provide energy, it thus seems logical that a desert mammal in the heat should provide its young with more water to prevent dehydration. When the lactating she-camel is deprived of drinking water, her milk becomes diluted to over 90% water. This logical reaction has been confirmed by endocrinological studies showing that all hormones involved in water homeostasis and milk production act to dilute milk in the same way as they act to dilute sweat. A similar diluting mechanism was also found in partially dehydrated cows and women. A 600 kg camel has about 200 litres of fluid in the alimentary canal and this is available for milk production, giving 20 litres per day for 10 days.

As fat is present in fixed amounts in milk, its percentage changes according to the water content. Hence a fall in water content will increase the fat percentage while an increase in water will decrease it. In the desert a high water content of milk with low fat percentage is a definite advantage. The fat does not form a layer on the camel milk when kept undisturbed, unlike cow milk, but is spread throughout the milk in small micelles. This makes the fat easier to digest as normally the bile and pancreatic enzymes must act to bring the fat to this state. Camel fat in general contains much higher concentrations of long-chained fatty acids (C-14 to C-18) rather than the short-chained fatty acids, which are most prevalent in buffalo and cow milk. Protein is present in sufficient nutritional quantities for human purposes.

Both salt and urea are essential requirements for the calf's and child's well being. The most important factor in the milk and human nutrition (besides the higher water content) is the high concentration of vitamin C. The vitamin C (ascorbic acid) has a powerful antioxidant action. The low pH brought about by the ascorbic acid stabilizes the milk and keeps it potable for relatively long periods. Refrigerated milk remains tasty for weeks. Camel milk is often virtually the only source of vitamin C for humans and shortages can result in serious complications in growth and brain function. Vitamin C also gives to the camel milk its sweet taste, often masking other tastes given to the milk by type of fodder eaten (bitter, salty etc.). The vitamin C content in camel milk is as high as 36 mg/kg, compared to cow's milk having an average of 10 mg/kg (Yagil, 2000).

Q. Write a note on lactation in camel.

A better understanding of its reproductive cycle and lactation can lead the camel to become an important producer of milk in hot arid regions. The camel has an advantage

over buffalo and cattle in hot climates of being able to continue eating. Some experiments with sucklings have shown that in the presence of adequate feed, fully watering camels only once every 10 days had no effect on milk production, whereas other workers strongly suggest that production is improved by daily watering.

The camel does not conserve water by restricting milk yield during periods of dehydration. It produces an increased amount of milk which is more dilute than normal and having a water content of >90%. This is thought to be a physiological adaptation to keep the calf hydrated. Production figures reported by various workers and from different countries are highly variable; up to 50 litres milk yield per day has been reported. If standardized to 305 days, lactation yields worked out to be 1200 litres to 10,700 litres. Camels grazing pasture were reported to produce 1,123 litres in a lactation of 13 months, with a production peak of 4.4 litres on day 56. As with yield of milk, the length of lactation also shows great variation. Depending on the reproductive status, management and frequency of milking, 9 to 18 months would appear to be reasonable. It is reported that camels tend to dry off when 4 months pregnant. With better feeding and delayed calf weaning; lactation length is usually prolonged.

The information available does suggest that sufficient variation exists for selection for milk yield to lead to significant improvement. However, in areas having a demand for milk, the shortage is so acute as to discourage the culling of any animal with udder and the inherent difficulty in producing a calf more than once every two years. A further constraint to milk production is the necessity of the presence of the calf to initiate milk flow and prolong lactation. High calf mortality then also adversely affects milk production. Whether this factor could be modified by selection, is not known. The camel does suffer from mastitis, but the incidence is much less than that seen in buffalo or cattle.

Q. Write an essay on endocrine control of lactation in the camel.

As in all body functions, hormones control all aspects of lactation. The combination of hormones which elicit udder and teat development as well as milk production and let-down are already well documented. However, specific hormones regulate milk production of the one-humped camel lying in arid areas. The four most prominent interrelated hormones are prolactin, oxytocin, aldosterone and vasopressin. Since the most important constituent of camel milk under the desert is water, especially in the dehydrated camel, it therefore, becomes clear why the aldosterone and vasopressin play such an important role in camel milk secretion. Prolactin and oxytocin prepare the udder tissue for milk production and after partus stimulate and maintain milk production. For most mammals it is accepted that prolactin is active only in the initial period of lactation, whereas further maintenance of milk production is dependent on oxytocin, which is secreted during evacuation of milk from the udder, either by suckling or milking. Since prolactin is important in combating the scarcity of body water, its secretion in the dehydrated camel will guarantee alimentary water absorption. However, it is the oxytocin secretion, brought about by milking, which *de facto* retains milk secretion. Thus extraction of milk determines milk secretion. This point is stressed because if the camel is not milked properly and milk is allowed to remain in the udder, hormonal control will

lower milk production. Camel herders are not aware of the importance of keeping a camel at its maximal milking capability and tend to skip milkings or leave milk in the udder. The practice of 'strengthening the calf' by not milking its mother for 4 to 5 days after birth will certainly depress milk production per day and per lactation period. Herders should be taught 'the more you take the more you get' or 'use it or lose it'.

In the dehydrated camel all the hormones, which act on the secretion of milk also act on the kidneys and alimentary canal to retain body water, making it available for the milk. Vasopressin and aldosterone have the same effect as in maintaining homeostasis i.e. retaining salt and water (Figure 19). In addition, the intermediate hypophysis changes anatomically and functionally to resemble neurohypophysis and therefore, more vasopressin and possibly oxytocin, are secreted. Another important factor is that vasopressin in large amounts acts as oxytocin and vice versa. In practice, therefore, large amounts of milk cause the secretion of large concentrations of oxytocin (and vice versa), which then acts to provide the necessary water by exerting an antidiuretic effect. Prolactin is an active initiator of salt and water metabolism, even in male animals. Its action on alimentary canal is similar to that of aldosterone, in a manner similar to vasopressin-oxytocin; when there is a need for salt and water, these hormones act similarly (Yagil, 2000).

Q. Discuss milking and the frequency of milking in camels.

Camels have four teats like those of buffaloes and cows. They are milked traditionally by men. Because of the height of the udder milking is done standing with one knee raised to support the milking bowl. Under most circumstances one-half of the udder is milked and the other one simultaneously suckled by the calf. Occasionally both udder halves are milked at the same time by two herdsmen. Not all camels accept this, particularly during the early stages of lactation, and in most cases the calf has to suckle first to stimulate milk let-down. In later stages of lactation, it is normally sufficient that the calf is present but does not need to suckle. Sometimes, when the calf is stillborn or dies early after birth, its skin is used to build a calf dummy that is shown to the mother to induce the release of milk. This is successful when the mother has had calves before, mostly it does not work with first calvers. In many such cases the mother will simply dry up within a week. These animals are quite often immediately bred again with good success.

The frequency of milking camels is variable and depends on supply of and demand for milk. Several factors affect milking frequency such as season, the quantity of milk produced per animal, the number of milking camels present, availability of other food for the herders household and sex, age and health of calves. Higher frequencies commonly produce a higher total yield, which is noticeable up to four milkings a day. It is not unusual to milk camel up to six times a day.

Q. Possibly what milk products can be made from camel milk?

For many years it was thought that because of its composition, it is difficult to convert camel milk into butter. There were apparently similar problems with making cheese. Recent research on the chemistry and biochemistry of camel milk and advances in processing technology have made it possible to make both butter and cheese without too much difficulty. Processing time may, however, be longer than for other milks and

techniques have to be adapted to the peculiarities of camel milk. Other traditional products such as fermented milks are not difficult to make and are highly appreciated by the owners.

Camel butter is pale in colour and sometimes has a slightly greasy texture. Milk takes a long time to cream, partly because of the size and distribution of the fat globules but also because camel milk fat contains a high proportion of fats with high melting points and a lower proportion that melt at about 15°C. Coagulation of cheese takes 2 to 4 times longer than for milk of other species but can be greatly reduced by adding 15g/100 litres milk of calcium sulphate ($CaSO_4$) or calcium chloride ($CaCl_2$). The usual bacteria can be used to form surface moulds (*P. caseicolum*) and blue cheeses (*P. roquefortii*). The taste of all types of camel cheese is generally acceptable to most people. Other products of lesser overall importance but which are made in various areas to suit local tastes are a variety of yogurts, soured milks, ice cream, Khir etc.

Meat

Q. Discuss in detail the production of camel meat.

Milk and work, in a wider sense, are the principal products of the camel. Meat is usually a by-product of a camel system and comes mainly from old males and females that have served usefully in other functions in earlier life. Only a limited number of castrated males are raised especially for slaughter. Of course, there are sizeable exceptions to the camel meat as to its being a by-product of a camel system. For example about 0.17 million camels are slaughtered in various countries by well-to-do adult Muslims on their annual religious festival called Eid-ul-Azha. At least 50% of this number are young male camels aged around 4 years. Many people keep and very fondly raise the camels simply for the sacrificial slaughter on this annual festival. The number of sheep, goats and cattle slaughtered by the Muslims with the same objective on this religious occasion around the world far exceeds 12 million.

Camel meat is a good source of protein but a lesser source of energy. The meat of one average sized camel will provide a person with 35 days supply of protein but only 5 days of energy. While camel meat is usually from old animals, it often has a specialized market. Camel meat markets, except in Sudan, are not well developed, but lucrative export opportunities to Egypt, Libya, Saudi Arabia and Gulf States do exist. It has been scored as high as or better than beef by taste panels in the Arab states. Even outside Arab States, meat from young camels has been graded as having the taste of a good beef. Camel meat is usually only a small proportion of the meat consumed in a country. In Pakistan, approximately 70 to 75 camels are slaughtered daily in various slaughterhouses except on meatless days. In several African and Asian countries, the consumption of camel meat is equivalent to 5 to 50% of nationally produced red meat. The meat is usually eaten fresh, cooked as such or in minced form, but is sometimes air-dried. Meat from camel is also used for sausages, in which form it has cooking and taste qualities similar to those made from beef.

Dressing percentages of camels are in the range of 45 to 55%, exceptionally up to 60% (Table 11). Using standard cattle butchery procedures, forequarters comprise about 34% of the total carcass, while the hindquarters constitute 25%. The rest of the carcass

includes about 5.0% liver, heart and lungs, with the head being 3.6% and the feet about 4.3%. The wet hide is equivalent to about 10.0% of liveweight and the blood to about 3%. A detailed study of 52 fattened male camels in Sudan, whose average body weight was 456 kg (range (395 to 512 kg), produced the following information. Dressing percentage was 55.8 when animals were slaughtered full and 63.6% after a fast of 48 hours. Individual body components were weighed and expressed as a percentage of fasted body weight, given in parentheses here: head 14 kg (3.5%), hide 35.8 kg (8.6%), gut full 54 kg (13.9%), stomach empty 10.3 kg (2.6%), intestines empty 15.4 kg (3.8%), mesenteric fat 6.6 kg (1.4%), kidneys 1.7 kg (0.4%), lung, trachea and diaphragm 5.9 kg (1.5%), heart 2.7 kg (0.71%), four feet 14.4 kg (3.6%), spleen 0.5 kg (0.1%), testicles 0.6 kg (0.2%) and tail 1.4 kg (0.4%).

Reports of weight gains in camels vary greatly. Some are randomly quoted here. Under open range conditions liveweight increase of 1 kg/day has been reported. In Egypt, animals fed on a high energy diet compounded from cottonseed, rice, molasses and mineral mix gained 150 kg body weight in 6 months (almost 0.82 kg/day). Well fed young camels under intensive conditions have gained 0.58 kg/day. In tribal situations, 222 g/day have been recorded in poor years to the age of 6 months, and 655 g/day in wet years when the calves were allowed to take all the mother’s milk.

Table 11. Live and carcass weights and dressing percentage of Sudanese camels from Darfur

Parameter	**Sex**		
	Male (n=21)	**Female (n=39)**	**Total (n=60)**
Liveweight (kg)			
Mean	447.9	414.4	426
Range	305.5-581.0	307.5-522.5	305.5-581.0
Carcass weight (kg)			
Mean	231.3	196.3	208.5
Range	144.0-310.0	141.0-248.0	141.0-310.0
Dressing percentage			
Mean	51.4	47.4	43.8
Range	46.2-55.6	41.3-53.5	41.3-55.6

Source: Wilson (1978).

Camels can utilise urea, molasses, dried sugar tar and poor quality feedstuffs treated with ammonia. These reports suggest that feedlotting may be cost effective. It may be possible to combine a system of low cost open range breeding with an intensive finishing period. Reported liveweight variation in camels suggests an ample scope for genetic manipulation and development of a meat type (Manefield and Tinson, 1997).

Q. Write a brief note on composition of total carcass of camel.

Total carcass composition is about 66% muscle, 19% bone and 14% fat, the latter being mainly in the hump. Lean meat has more moisture and less fat than beef, with the pH

being about 5.75. Muscle has 75.5% water, 21.4% protein and 1.4% fat. As a percentage of cold carcass, proportion of muscle was 56% bone 19% and carcass fat 13.7%. The latter figure would vary according to the degree of fatness of the animal, its conformational type and environmental factors. Bactrian camels have been reported with 25% carcass fat.

Q. Give average and range of birth weights of various breeds of Arabian camels and the factors that affect these weights.

It is probable that birth weights differ significantly among breeds in the same area as shown by averages of some breeds in Pakistan and India. Weights at birth are

Table 12. Birth and mature weights and weight gains of various camel breeds

Parameter	**Pakistan breeds**			
	Kachhi	**Gaddi**	**Bagri**	**Dhatti**
Birth weight (kg)	44	41	44	40
Mature weight (kg)	662	589	656	570

	Indian breeds*		
	Bikaneri	**Kutchi**	**Jaisalmeri**
Birth weight (kg)	38.8	31.8	31.0
Mature weight (kg)	669.4	506.0	580.0
Average gain (g/d) 0-3 months	642	786	752
3-6 months	-	540	458
6-12 months	134	290	227
1-2 years	189	186	208

* Source: Adapted from Anonymous. 1990. Annual report, National Research Center on Camel, Bikaner, India.

also influenced by dam nutrition, health status and health care. Gestation length seems to have some effect on birth weight. Season of year and parity also influence this parameter. In contrast to many other species, female calves are usually as heavy as or heavier at birth than males. Birth weights range from 25 to 45 kg (Table 12). Heritability of birth weight is probably higher in camels than in other species. This suggests that it could respond rapidly to selection. Improved nutrition and better management are probably appropriate improvement paths to achieve heavier birth weights (Table 13). Heavier birth weights should result in better calf survival and consequent overall improvement in herd performance.

Table 13. Average birth weight of camels from various countries

Country	**Birth weight (kg) (mean ± s.e.)**
Pakistan	43.5
India	41.9 1.35
Tunisia	27.2 0.65

Libya	35.0	
Saudi Arabia	39.1	0.57
Israel	32.5	3.30
Sudan	26.2	2.80
Kenya	27.8	

Source: Modified from Wilson (1998).

Q. Give a brief account of mature weights of one-humped camels and the factors that may influence these.

Mature weights range from 400 to 800 kg. These weights are mainly related to breed or type of the camel. An animal's genetic make-up is usually the most important factor in its final mature weight. The effects of management, nutrition and health care can, however, influence the time at which the mature weight is reached. This has been amply shown in Kenya where Rendille-Gabbra camels in a traditional pastoral system do not reach 400 to 500 kg mature weight before about nine years yet achieve this range at four years under ranch conditions. Benadir type camels on another ranch reach 600 to 700 kg by five years, whereas traditionally managed herds have animals of this weight only at older ages. Male Ogaden camels in south-east Ethiopia weigh about 685 kg at maturity in the traditional system, while females weigh 525 kg. Better management and health care such as deworming and removal of ticks coupled with mineral supplements and feeding from lower grazing pressure areas and higher rainfall can thus pay handsome dividends in camel production. These dividends are reduced age at sexual maturity when the animals can be bred or can be sold for meat or as transport animals. Mature weight of camels in Pakistan on average varies from 550 to 740 kg.

Q. Discuss the daily gain in body weight of dromedaries in some of the African and Asian countries.

Daily weight gains of camels vary from 300 g to more than 1000 g for animals from birth to one year old. In Saudi Arabia, males and female calves grow almost at the same rate, with daily gains from 780 g/day in the first month after birth to 1040 g/day in the fifth month and then decline to 400 g/day in month twelve. There is found an inflection in growth curve (i.e. slow growth) at 4 to 5 years age, this being a normal occurrence in all livestock as they approach mature size (although it occurs at different ages in different species). Allometric (unequal) growth results in relatively more rapid increases in linear body size than in weight. For example, in Tunisia, camels at first conception were only 64% of final weight but averaged almost 90% of final size in six linear measurements. Weight changes can be influenced by management interventions and by improved nutrition. The cost in weight gain of restricted access to water was that 12 to 14 month old camels of about 200 kg liveweight gained 430 g/day over six months on daily watering while only gaining 380 g/d when watered weekly. Breeds with lighter birth and mature weights may gain weight more rapidly than breeds of heavier weights and thus may become physically mature at an early age.

Rates of feed intake in relation to liveweight gain are generally in the ratio of 4 to 8 kg for each kilogram of gain. In other words, 22 to 29 MJ ME are needed for every kilogram of weight gain for young animals. Of course, more energy is needed for older animals

whose efficiency of growth is reduced as they approach mature weights. Nutrition and management interventions are more effective in increasing weight when used early in life. Calves in Israel gained 870 g/day in very early life at a metabolisable energy intake of 19.45 MJ/day with an average daily gain of 680 g up to 180 days age. Animals one year old in Tunisia fed 175 days on oat hay *ad libitum* and a concentrate of wheat bran and olive pulp gained 326 to 565 g/day (with a linear relationship of y = 284 + 5.4 x, where y is weight in kg and x daily dry matter intake in g/kg$^{0.75}$), eating 1.6 kg DM/100 kg liveweight or 61 g DM/kg$^{0.75}$ per day at a conversion ratio of 7.4: 1.0. Heavier camels (665 kg in Ethiopia gained only 100 g/day over 90 days at lower intake levels of about 1.25 kg DM per 100 kg or 50 g DM/kg$^{0.75}$.

Q. How would you determine the weight of a camel at a particular age?

Weight at a particular age may be determined from regression equation provided some prior data are available. For Bikaneri camels a linear relation of y = 90.53 + 0.29 x (where y is weight in kg and x age in months) accounted for 94% of total variation. Heritabilities of weight at 6, 12, 18, 24 and 30 months age have been estimated as 0.52, 0.40, 0.29, 0.12 and 0.31 in India.

Weight at a particular age is mainly a reflection of gain in body weight. It is influenced to some extent by birth weight as well as by the same genetic and environmental factors that affected weight gain in camels. The month and the year in which an animal is born are the most important factors affecting weight as these two periods effectively control the amount of feed available to an animal. The influence of these two periods is, however, progressively reduced with age. The number of calves already born by their dam affect weight at young ages only. Compensatory growth occurs from about 24 to 30 months of age and it is this phenomenon that causes most other effects to disappear after this stage.

Q. Discuss various means of determining the body weight of camels. Also indicate the purpose of carrying out this exercise.

Determining the liveweight of camels is necessary in deciding on breeding, culling, slaughtering and in rare cases in feeding them. Body weight is rather important for proper dosing with drugs. Because of their height camels cannot be weighed in regular buffalo and cattle weighing crates, which usually have small weighing platform. A specially designed weigh bridge with a large platform and a dial should be used for weighing camels. Hydraulic or electronic platforms are also available. The former is a cheap alternative.

Body weight of camels can be calculated from body measurements as is done for other farm animals. Boue (1949) as cited by Schwartz and Dioli (1992) had developed a formula for estimating liveweight of the camel based on three measurements of its body. If these measurements {i.e. shoulder height (H), thoracic girth (T) and abdominal or hump girth (A)} are taken in metres, weight in kg can be estimated from the following formula: Liveweight = 53 x (TAH). This formula was applied by Schwartz *et al.* (1983) together with weighing on a hydraulic weighing platform and used a slightly modified formula (Figure 20) (all measurements in metres). Liveweight (kg) = SH x TG x HG x 50 (Table 14).

Table 14. Correlations between body measurements, estimated and exact liveweights of small East African camels on a ranch, Laikipia District, Kenya (n = 328)

	SH	TG	HG	Exact weight
Estimated weight (EW)	.93	.95	.95	.98
Height (SH)		.95	.92	.95
Thoracic girth (TG)			.94	.97
Hump girth (HG)				.94

Source: Schwartz (unpublished).

The three body measurements were highly and positively correlated to each other. It is therefore possible to use only one of them to estimate liveweight with a little error margin. The thoracic girth appears to be the most reliable parameter in this context. Liveweight of tall and selender camels, like the racing type or young calves of all types will be overestimated if the same numerical factor is used, whereas the liveweight of short and compact animals tends to be underestimated by this formula. Accordingly, the numerical factor in the formula has to be adjusted to age/type of animal.

Q. What normally is the rate of growth of world population of one-humped camel and what factors may affect this rate?

Estimates of numerical increase in world population of one-humped camel have averaged about 1.16% per year over a period of 15 years from the late 1970s to the mid 1990s. The proportional increase in numbers has been slightly less in Africa (1.14% per annum) than in Asia (1.18% per annum). However, in Africa, numbers have increased more rapidly in countries that already had large camel populations and where they are an important part of the agricultural and national economies. Some 70% of the one-humped camels in the world are kept in pastoral systems in eastern and north-eastern Africa. Here it is the need for milk that drives the system and the potential for meat is largely ignored by the owners. In East Africa, dairy herds mostly consist of breeding females while in other herds where transport is still important, there is greater percentage of males but females usually still predominate.

The age and sex composition of the herd influence in part the rate at which a population increases. Other parameters that affect population growth are reproductive performance and mortality rates (Table 15). Camels are large, slow maturing and long-lived animals. Population growth rates thus tend to be slower than for the other farm animal species. Off-take of males for slaughter at three years and upwards also needs to be accounted for.

Table 15. Production parameters affecting herd structure and population growth in certain farm animals under dry land conditions

Parameter	Animal species			
	Goats	Sheep	Cattle	Camels
Age at first parturition (months)	15	15	48	60
Number of young per parturition	1.4	1.05	1.0	1.0

Interval between parturitions (months)	9	10	20	24
Number of young per female per year	1.8	1.4	0.7	0.5
Mortality rate to 12 months (%)	35	35	30	50
Mortality rate after 12 months (%)	10	10	7	5

Source: Wilson (1984).

Q. Discuss the prospects for improving the production of camel meat.

Meat production efficiency of a livestock species is affected mainly by two factors. One is the reproductive efficiency influencing off-takes, the other is the individual growth potential. As already pointed out, camels, due to the intrinsically low reproductive rate, cannot be efficient meat producers. Off-take rates of 3 to 5% might already constitute a stress on the population. The fact, that all camel populations in many African countries and some of the Asian countries according to some estimates, with a few exceptions, are either declining or are stagnating in numbers, proves that a pronounced consumer preference for camel meat combined with strong purchasing power can be detrimental to population growth. The individual growth is determined by sex and genetic potentional. Genetic improvement is faced with the same constraints as were pointed out for milk production.

The most powerful interventions to improve meat production in camels are improving nutrition especially of the calves, early weaning of calves and reducing mortality through hygiene and health care.

Since production in the traditional subsistence system is mainly geared to milk production, male calves are thus considered of little future value and face a much stiffer competition with the herders for their dam's milk than female calves. They are often allowed to suckle only one teat, or are given access to the dam's udder after all teats have been milked, whereas female calves usually have regular access to two teats. Consequently the pre-weaning survival rate of male calves is less than half of that of females and weaning weights are lower. Total productivity on the other hand is higher in dams with male calves due to the high milk off-take for human consumption, with milk accounting for approximately 80%. In females with female calves, milk off-take for human consumption contributes only 30% of the total. This trend to deprive the male calves of their due share of milk is evidently detrimental to their growth which in turn adversely affects their potential to produce meat.

Q. Are slaughtering and skinning of camels done in a different manner than for other large animals? If so, discuss briefly.

In contrast to other livestock species, camels are slaughtered when they are in sternal recumbency. The reason being that camel would require a scaffold at least 4 to 5 m high to facilitate butchering a hanging carcass. Butchering camels lying on the back is also not practicable because the distinctly arched spine and the hump make balancing the carcass virtually impossible. Instead camels are seated in a normal posture, front and hind legs are tied, the head is bent sideways and backward, and with a quick incision all major

cervical vessels at the base of the neck severed. Immediately after the nuchal ligament is cut just in front of the shoulder, so that the neck and the head rest on the ground. Death is immediate. The carcass is kept in sitting position. For better balance of the carcass the hind legs are pulled backward and outward.

Skinning begins with a long incision along the spine and the crest of the hump. The skin is removed down the sides and cut off the legs before the elbow and knee callosities. Butchering begins with splitting and removal of the hump. Removal of the various cuts is always done symmetrically to maintain the balance of the carcass. The spine and the long muscles of the back are left intact until all internal organs are taken out. Then the spine is cut out between the withers and the pelvis and the remainder of the carcass collapses and is cut into smaller pieces. At last the skin is cleaned out and cut in two symmetrical pieces. If there is no immediate disposal of skin, it should be salted and spread over a wooden frame.

Work

Q. Give a list of various types of work performed by the camel.

Camels are used as riding and pack animals, to pull carts and to provide draught for various agricultural operations such as ploughing and seed-bed preparation, operating chaf cutters and cane crushers and drawing irrigation water from deep wells. They are a power source for small scale oil mills and grain grinders. Loading camels are regularly used to carry firewood and trade goods. In farflung desert areas camels perform transport functions during migrations and most importantly carry water for household consumption.

Q. Give an overview of work performance of the camel.

Probably no other domestic animal performs as wide a range of power functions in support of man as the camel. They still make a major contribution to the energy needs of urban and rural communities in most areas of their distribution. Under traditional pastoral livestock production system, migration might range from once/twice in Pakistan and India to six times per year in several countries in Africa. Of crucial importance to these migratory systems is availability of adequate numbers of loading camels for haulage of households, water etc. Migration distances might be short or extend over a few hundred kilometres. The performance of camels as draught animals compares favourably with oxen and equals that of horses (Table 16).

Besides household needs such as water, camels commercially carry building material, grains, salt and many other goods in Niger, Mali and Ethiopia. In Pakistan and India, camels drawing pneumatic-wheel carts deliver many urban goods to individual service points more economically than motor transport. This is because the capital cost of a camel and cart is lower and it is not expensive in spare parts. Other considerations in this context are that it does not pollute the environment with carbon monoxide fumes and with noise.

Camels seem to be equally as efficient in producing draught as most other species. However, harness and yoke system used should be comfortable and such that cause no injury to the camel. The camel is also used for individual transport as a riding animal. It is still very common in rural areas in many countries. Camels still serve as mounts for

army, rangers/border police in some of the Asian and African countries, but their importance is declining. On the other hand, their monetary value as racing animals has increased tremendously in recent years. Camel racing and other sports and leisure activities such as pleasure riding, trekking and camel safaris have recently become a tourist attraction in many parts and developed into a minor industry.

Q. Give below the normal walking and trotting speed of an average camel and the weight it can carry easily.

Camels walk on average at the speed of about 4 km/hour and trot at 10-12 km/hour, while they can run over short distances at about 32 km/hour. Camels can carry load's up to one third to one half of their body weight over a distance of 60 km per day.

Table 16. Sustainable draught power of various animal species for ploughing

Species	Liveweight (kg)	Sustainable draught power		Working speed (km/hr)	Daily working time (hr)
		Relative (% liveweight)	Absolute (kp)		
Donkey	125	20	25	2.0	3-3.5
Horse	300	12	35	2.7	5-6
Oxen	350	14	50	2.4	4-6
Camel[1]	450	8	35	2.5	5-6
Camel[2]	450	12	54	2.5	5-6

1 = If absolute draught power is assumed to equal that of a horse.

2 = If relative draught power is assumed to equal that of a horse.

Source: Schwartz and Dioli (1992).

They can carry as much as 200 kg with relative ease but are often asked to do much more, for which there is a price to pay in slower speeds and extended periods of rest. On camel carts having pneumatic wheels, a single camel can pull a load of over one ton. About two and a half decades back, a team of 16 camels in Australia used to pull on rough roads loads of 8 tons at speeds of 2.5 km/hour.

Q. What pattern of settlement around water points is followed by camel raising desert dwellers?

Camels are vital for nomads/desert dwellers for their personal transport and for moving the camp, carrying firewood and water and for earning cash through transport for third parties. They usually follow a natural pattern for locating their camping units around watering points. Those having 1 to 2 camels will settle within less than 3 km from the watering point, whereas those with 3 to 4 camels would camp within 5 to 6 km and such nomads as having 8 or more camels would locate their camping units beyond 10 to 12 km from the water source. Browsing/grazing areas close to a water source are usually in poor condition, due to high grazing pressure and present a higher contamination risk with respect to intestinal and ectoparasites. Pastoralists who are forced to maintain their herds here have a limited choice of pasture resulting in limited milk and meat supply to the household and can thus adversely affect the quality of herd management.

Leather, Hair and Wool and Manure and Blood

Q. Discuss the production of leather from camel hides.

Reliable data in respect of these by-products from various countries of Africa and Asia are not available. About 22500 camel hides including those of animals slaughtered annually by Muslims on the religious festival of Eid-ul-Azha are obtained in Pakistan. Of these 15 to 20% hides are damaged. These are used to manufacture saddlery, sandals and beautiful decorative articles some of these items are exported as well.

Some time back the people had poor opinion about the leather made from the camel hide, but the better processing of the hide in Sudan and the use of better technology in Australia have shown encouraging results. By splitting the hide, thus allowing the hump section to flatten, tanning has been performed in commercially available machines. Vegetable tanning produces a soft leather suitable for craft work and the tourist industry. Chromate tanning produces a harder leather suitable for commercial applications, but still useful for selected craft work.

It has been found that camel hides do not lack strength and possess 5 times the pulling strength of bovine hides. Work in Sudan indicates that camel hides are superior to cattle hides in many ways such as these flay and flesh more easily, are 60% heavier than cattle hides, the large neck area in camels makes good leather and the crust leather yield from camels is 50% more than that from cattle. Camel hides absorb salt better, cure better and dry faster than cattle hides. Dehairing of camel hides is faster and deliming and tanning better and therefore split easier. The tensile strength is 20% greater than cattle leather. The finished chrome tanned camel leather is denser yet softer than the cattle product. When made into ladies handbags, spectacle jackets, wallets and shoes, acceptancewise these products were graded higher than the same products made from cattle leather.

Q. Are camels in Pakistan a substantial source of obtaining hair, wool, manure and blood?

The production of camel hair makes a negligible part of the about twenty thousand tons of hair produced in Pakistan. However, as in other camel producing countries, these are used locally for manufacturing blankets, floor mats, tent cloth and ropes. Manufacturing of these products provides living to hundreds of people. Wool yield from camels is much lower than the hair produced by them. Calves are born with a soft woolly fleece, which usually can be shorn once. The yield approximately varies from 0.5 to 1.0 kg of raw wool. This wool is mixed with hair in manufacturing blankets.

Camel raisers leading a nomadic life are most of the time not involved in agriculture. However, many farmers having cultivable land keep one or at the most two camels. The excreta of these animals obviously becomes a part of the farm yard manure produced by other farm animals such as buffaloes, cows, sheep/goats maintained by the farmers and as such is used for fertilizing their lands.

Blood of camels slaughtered in regular slaughterhouses in Pakistan is collected along with the blood of other animals slaughtered there, but no separate precise figures are available for camel blood. The blood thus collected is dried/sterilized and used as blood meal in animal feed especially poultry feed. Such data concerning most of the countries possessing camels are lacking.

The Turkman one-humped camel from southern central Asia produces about 2.5 to 2.7 kg fibre per year with a diameter of 12-27 µm and a length of 4 to 12 cm. Compared to most of the African and Asian one-humped camels, the Bactrian and South American camelids yield fibre which is much better quantity- and qualitywise.

Q. Are South American camelids and Bactrians a good source of wool and hair production?

Both types of fibres, wool and hair, are found in the coats of camelids. The worlds most highly regarded wool is obtained from the South American camelids, especially the Vicuna. Among the old world camelids, the Bactrian is superior to the dromedary as a wool producer.

The entire camel is covered in wool and hair that vary in length according to the season and location on the animal. The longest hairs are seen on the hump, shoulders and under the throat. Coat colour ranges from almost white through brown and fawn to almost black. Two coloured camels are common is some regions. Fibres are grouped in clusters except on the lip margins, external nares and lower eyelids. This arrangement may assist the camel to evaporate sweat at the skin surface rather than on the hair tip. Coat over the back may reach a length of 40 cm in the Bactrian and alpacas. The long coat sheds and tends to be rubbed off during the summer season. Even then it protects from radiant heat, and camels, which are mistakenly shorn for comfort may suffer from increased heat stress. Camels permanently domiciled in equatorial regions tend to have a sleek, glossy coat the whole year round. Reflection from such a coat helps to reduce radiant heat absorption.

The wool of the camel has had times of demand for textile production and reports indicate that currently there is a strong resurgence. The coarser fibre is used for the manufacture of tents, carpets and blankets. Large Bedouin tents are still used. The fine fibres are used for the manufacture of coats. Shearing takes place once a year in spring. The finest camel wool is obtained from the coat of the Bactrian yearlings. The fibre diameter is 16 to 18 µm (fine Merino wool is 18 to 19 µm) with 85% of fibres non-medullated. In Mongolia, adult Bactrian males may produce up to 15 kg. The average herd yield is 5 kg. About 25% is long coarse fibre shorn from the knees, elbows and chest. The remainder, with a fibre diameter of 21 to 29 µm comes from the body and sides of the neck. Wool production is the primary goal of camel keeping in parts of China, Mongolia and eastern parts of the old Soviet Union. In cold climates the dromedary may produce up to 5 kg of hair annually but 2 to 3 kg is more usual. Australian camels give heavier yields than those in the Middle East. Temperature in winter nights in Australian deserts often falls to minus 9 to 10°C. The wool from the adult male dromedary has a fibre diameter of 31 to 35 µm. Finer wool is produced by yearlings with yields of 1 to 4 kg. There is a camel wool farm on Blackspur in Victoria, Australia. Prices realised for the product are reported as 250 to 300/kg Australian dollars when carded and spun.

Q. Discuss the comparative productivity of camel. Give your reasons in favour or against.

The camel's supposedly low productivity must be seen in the context of low inputs and the harsh conditions to which it is adapted. The camel's comparative advantage lies in its ability to produce and to thrive in areas where feed and water are limited, where climatic and other environmental stresses are severe and where other domestic species are incapable of similar performance. In addition to work the camel produces large amounts of protein relative to food energy for human use.

The value of the camel in harsh environments is, perhaps paradoxically, best shown by its limited increase in productivity in response to improved conditions. In comparison with other main farm animals, improvements in output are only half those of goats, about one-sixth of that of sheep and only one-eighth those of cattle. Instead of criticizing the camel as a domestic animal, this response failure is a powerful argument in favour of its husbandry in difficult areas. Improved management, feed and water supplies coupled with proper health care do result in increased output from camels. Such interventions should always be used, however, in the context of the economic and biological environments.

Nomadism and transhumance are the main elements in traditional system of camel raising. Camels have rarely been kept as the only species in a production system, either at local or at larger scale and their has almost always been herding of a mix of species yielding a range of products including milk, transport, power, meat, wool and hair. The keeping of a mix of domestic animal species is a common strategy to reduce risk. Pastoralist strategies are in fact designed to minimize the risk of destitution and not to maximize production. Production (total output) and especially productivity (output in relation to inputs) is therefore difficult to quantify, however, both are often considered to be low or poor.

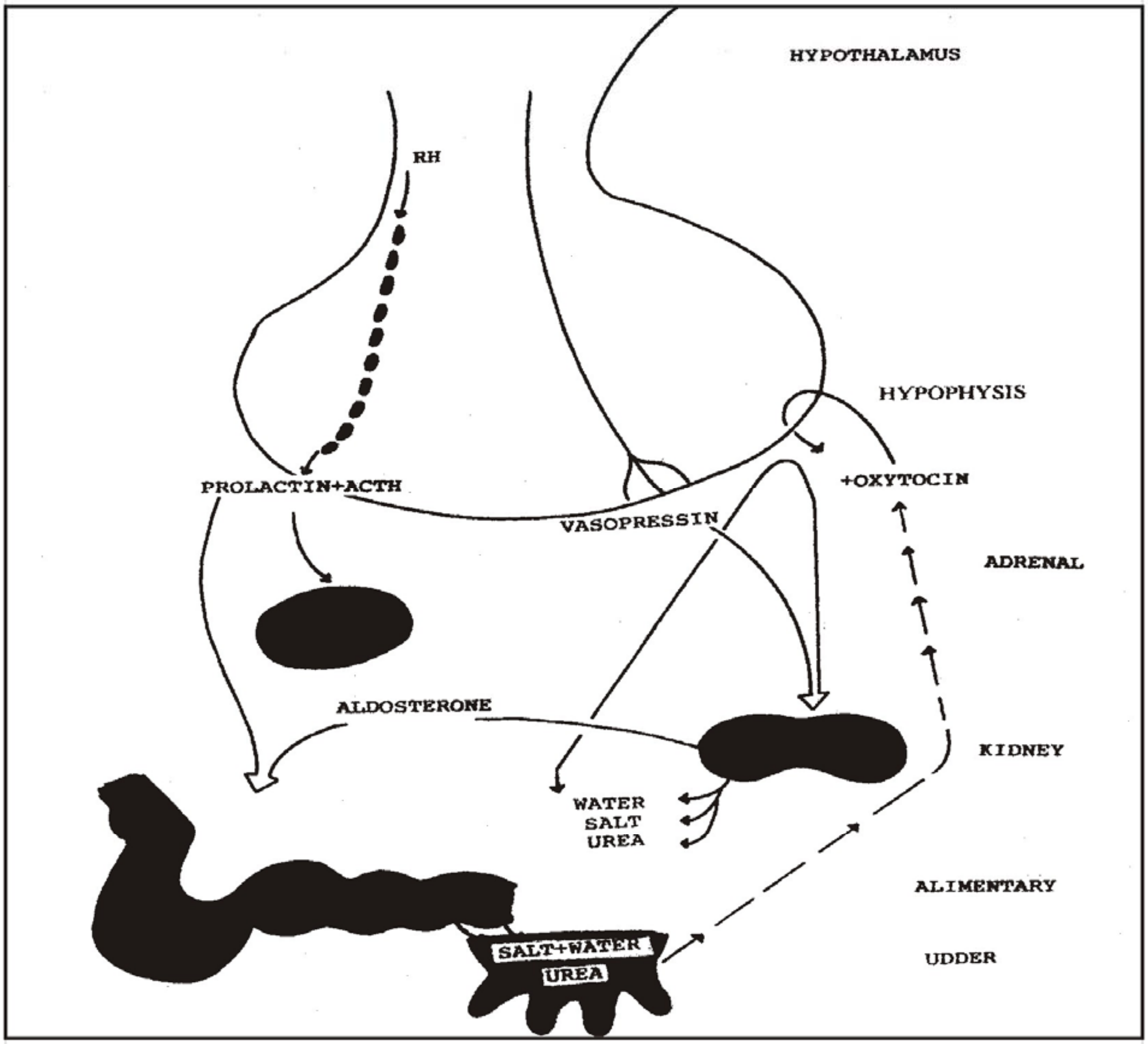

Fig. 19. Endocrine control of lactation in the dehydrated camel
Source: Yagil (2000).

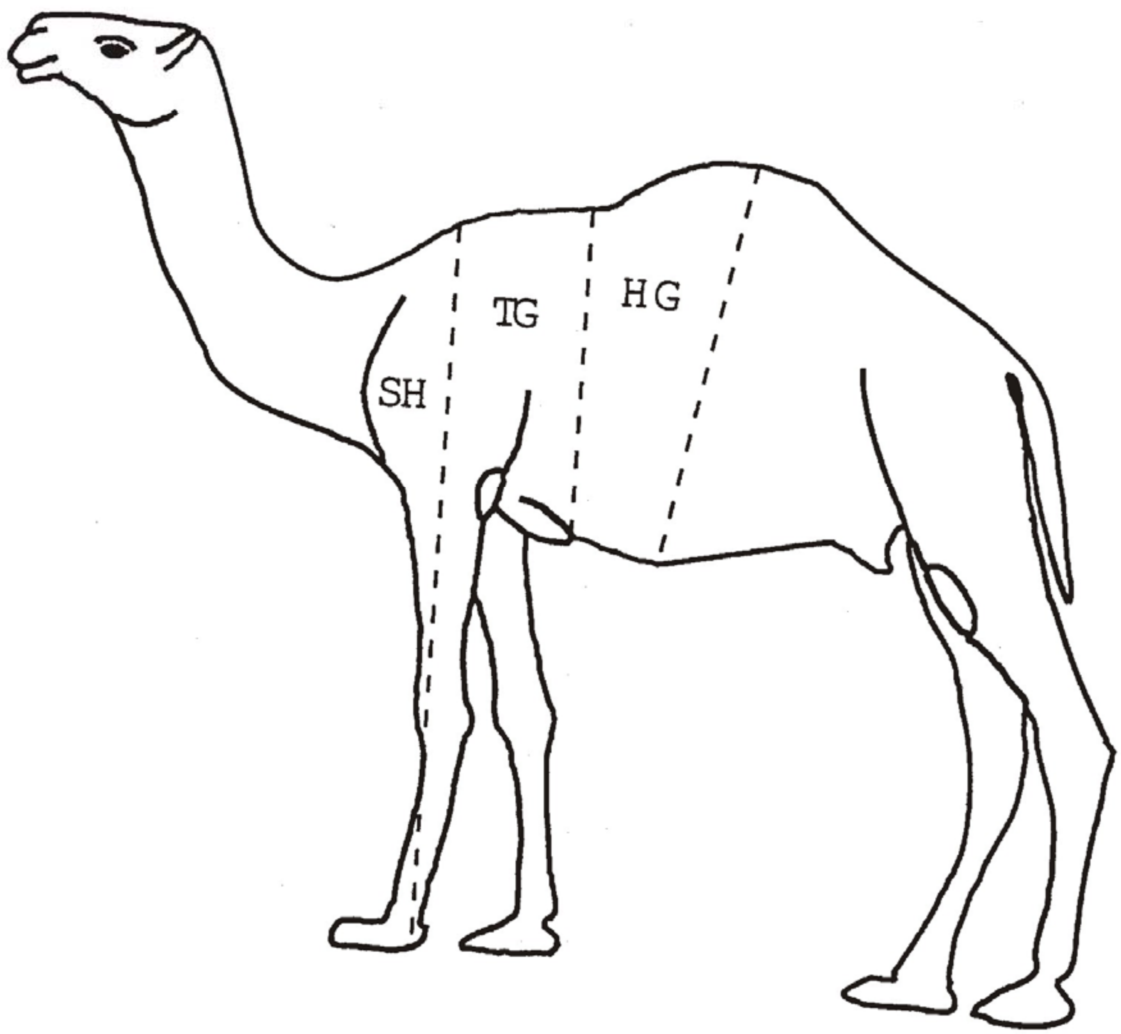

Fig. 20. Body measurements for the calculation of liveweight in camels using the formula: Liveweight (kg)=SH(m)xTG(m)x HG(m)x 50[SH=shoulder height; TG = thoracic girth; HG = hump girth] Source: Schwartz and Dioli (1992).

PRODUCTION AND MANAGEMENT

OF

CAMELS

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PREFACE

The camel, without exaggeration, is the most ignored among the domestic ruminants in Pakistan. This is as much true in terms of lack of efforts to improve its care and productivity as it is in terms of lack of any planned research on it. Had it been an unproductive and a useless animal, its population would have gradually diminished, but it is the other way round. Its population is steadily growing. On papers, its population is being shown as stagnating, but most probably it is not so. On the international scene, there seems now a growing awakening in respect of the camel. At places, it has been termed as a ‘food security animal’.

In Pakistan too, some teaching institutions have taken an initiative and have incorporated “Camel Production” in their teaching courses. No doubt, it is a very timely step.

Scientists from Germany, England, India, Australia and UAE have published books on camel. These are, of course, good books but as usual their prices are prohibitive for our students, extension workers and even for teachers. Moreover, these books contain a little information about camels in Pakistan. Therefore, an easy-to-understand book on ‘Production and Management of Camels’ using a question-answer format, has been compiled. This should provide ready-made answers to so many questions simmering in the minds of students, teachers, researchers and extension specialists. It embodies about 400 questions along with their answers.

The book discusses the distribution of camels in different continents/countries, breeds and types of camels with cross reference to other species, nutritional physiology and reproductive management, the way camels adapt to hot arid environment, milk and meat production and work performance, practical management and training of camels, marketing, health care and some diseases, including valuable information on several other aspects. Camel breeds and camel raising practices in Pakistan have been adequately discussed.

We feel great pleasure in acknowledging the hard work done by so many researchers/authors/editors, whose published information has been used, mostly as such, in compiling the book under reference. Their efforts have been amply acknowledged in the text/tables/figures etc. It was beyond our means to individually contact them in this regard.

We are highly thankful to Akhter Saeed MD for providing us useful literature from abroad. We are equally thankful to Dr. Ghulam Muhammad, Chairman CMS, UAF, for his cooperation in providing pertinent literature. Ch Sikander Hayat and Nawaz Ahmed Sipra also deserve our heart-felt appreciation for helping us out of many problems pertinent to the publication of this book.

No book has ever been claimed to be perfect in all respects and so is this one. The readers are requested to convey in writing their suggestions about omissions/shortcomings noticed in this book. Their suggestions would not go unnoticed.

Bakht Baidar Khan
Arshad Iqbal
August, 2003 **Muhammad Riaz**

FOREWORD

For a long time the camel has been the victim of disregard and deliberate neglect of scientists and development workers. However, the last about two decades have witnessed a resurgence of interest in this species. Most of the work to exploit the productive potential of the camel has been undertaken by those who come from such countries that do not even possess camels. I think this should be more than enough to make us realize our responsibility towards a multipurpose domestic animal species, of which this country has a sizeable population. We need to investigate its peculiarities and exploit its potential especially in terms of milk and meat production and to explore the possibility of increased export of live camels to several Middle East countries. Presently some of these countries are importing camels from Australia.

To strengthen the possibility of implementing such plans, we must be equipped with recent knowledge about various aspects of camels. In this connection and as an animal scientist myself, I feel pleasure to mention that a book with the title ‘Production and Management of Camels’ has been brought out by experienced teachers/researchers, which should suffice to meet the needs as mentioned above. The contents of this book make me believe that it should be as much helpful for students, teachers and research workers as for extension specialists.

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PART – II

Part – II includes:

- *Production Systems*
- *Adaptation to Hot Arid Environment*
- *Management Practices*
- *Locomotion and Gaits*
- *Health Care*

PRODUCTION SYSTEMS

Q. Name the various systems that are in use for camel production.

Production systems involving camels have traditionally been very extensive and mobile. The following systems are in use:

a) Traditional system, b) Periurban system, c) Ranching, and d) Research stations (Wilson, 1998).

Traditional system is mainly subsistence oriented. Camel products are principally consumed in the family or used to bring in small amounts of cash where the situation allows. There is some exchange of products for creals and other basic foodstuffs. In most societies old and barren animals are slaughtered. Where milk is the main product and males are not much in demand for transport, breeding or racing, they are sold for slaughter and there is thus a preponderance of females in the herd. Where the transport role is still important, more camels are kept and there will be as many males as females in the herd. Camels are also used in many societies for lifting water from deep wells for other stock and the household needs. Camel milk usually contributes more to the total milk supply from all species in the dry than in the wet season (Table 17).

Table 17. Seasonal contribution of domestic livestock to supply of milk as human food in Turkana, northern Kenya

Livestock species	Seasonal contribution (%) to total milk	
	Wet season	Dry season
Camel	45	71
Cattle	12	10
Goat + sheep	43	20

Source: Schwartz and Schwartz (1985).

In Pakistan, the area occupied by nomads and transhument pastoralists is sandy desert in Cholistan and Thar regions, whereas in Balochistan it varies in character from desert to subhilly and hilly rangeland. Annual rainfall averages about 150 mm during the months of July to September with some in winter. Daytime temperatures can often reach 50°C and very high temperature prevails for several months. Night temperatures fall below freezing from November to February when day temperatures still reach 30°C. There is sparse woody vegetation of low thorny shrubs but this is rather thicker in some areas. Several species of Acacia are dominant. Ground cover is mainly sparse ephemeral grasses with some herbs.

During drought periods the pastoralists move to surrounding colonized areas in search of water and animal feed. In case of prolonged drought, state agencies and social organizations arrange to provide water and fodder through rail and road. Also, foodstuffs for herders and families are provided using helicopters. Severe droughts take a heavy toll of animal life especially cattle, sheep and to some extent goats and camels.

The system is totally pastoral. All income is derived from livestock and its products such as wool, hair and butter oil (Ghee) made from cow milk. There is now also some income

from off farm work and especially from the sale of labour. Concerned state agencies are trying hard to provide more water holes, roads and mobile health clinics for humans as well as animals in those areas. At some suitable places, the nomadic pastoralists have been allotted free of cost land to induce them towards sendentarisation.

Q. What is meant by periurban system of camel production? Give an outline of this system.

Periurban system is a special type of transitional system which indicates that camel systems have not remained isolated from the pressures of twenty-first century. Efforts have been made in certain parts of Africa and Asia to form cooperatives and owner's associations with a view to improve camel production and to inculcate in producers some political and economic awareness.

In Pakistan, around the city of Karachi there are colonies with a current total of perhaps 250000 buffaloes and unknown number of camels that provide milk for the city. Similarly, there are several mobile periurban camel dairies in the suburbs of big cities such as Faisalabad, Lahore, Multan and Hyderabad, consisting of 5 to 10 camels each. The women of camel herders each carrying about 15 litres of milk move about in the city suburbs like hawkers and sell their milk. The camel dairies move from one suburb to another and then may shift to another city. There are periurban camel dairies in Africa in Djibouti, Mauritania, Morocco, Somalia and Sudan.

The system, however, seems transitional, in that it will not be sustainable in the long run since urban populations increase and environmental concerns become more important. In Mogadishu women sell a combined total of as much as 5000 litres milk per day. The drift to urban areas has increased manifold in recent years, resulting in profound changes in lifestyles (Table 18), coupled with willingness to enter into new systems of production. It is accompanied by changes in animal management, nutrition, health interventions and attitudes to commercial production. These changes are often at the expense of cultural and traditional family ties and mutual help.

Table 18. Changes in lifestyle of the Mauritanian population (1965-92)

Lifestyle	Year			
	1965	1977	1988	1992
	%	%	%	%
Nomadic	73.3	36.4	12.0	10.9
Sedentary	17.6	42.0	46.9	44.5
Urban	9.1	21.6	41.1	44.6

Source: Wilson (1998).

Periurban system is intermediate in nature and will probably gradually be displaced to more and more distant suburbs and eventually return to rural areas. Their management there will benefit from the techniques such as feeding systems, general management and milking practices learnt in the town systems. In the meantime they are an effective way of supplying increasing urban demand for livestock products in a relatively efficient way using local resources.

Q. In contrast to traditional systems describe ranching, a relatively new system of camel production.

Ranching of camels in the commercial sense is a new system of camel production although it is still relatively rare. Ranching of camels is in operation in north-central Kenya where camels literally add more than one new dimension to the system. They add a vertical dimension because they are able to make use of the upper layers of the thornbush savannah that cattle and sheep and even goats are unable to convert into animal protein. They add a horizontal dimension in further diversifying the risk of failure from the normal meat-producing operations due to drought, feed or water shortages. Yet another measure is added to the opportunity to generate more income through tourist use for trekking or adventure holidays.

Camels were first used in a limited way on Kenya ranches to transport water for young stock and for the herdsmen and to provide milk for the herdsmen so that they would not compete with cattle calves and thus reduce their growth rate. It was soon realised, however, that camels could play a full economic role in the operation. They allowed the total domestic herbivore biomass to be substantially increased without putting pressure on the real carrying capacity of the land.

The ranch camels are now an integral part of the commercial operation. Superior bulls have been imported from Pakistan to improve milk production. Meat supplies can be guaranteed over a longer period. Adventure trekking holidays are provided for local tourists. Camels are in use for experimental purposes by the university, animal health service and by one major international organisation. Genuinely improved animals have been sold back to the original pastoral owners (Wilson, 1998).

Q. What role research stations/experiment stations can play in improving the various aspects of camel production.

The new commitment to the camel is evident from the increasing interest shown by a number of countries where university camel herds or national herds have been established. India probably is at the top of the list where the National Research Center on Camel in Bikaner was established in 1984 with full financial support of Government. Well managed research centers with adequate numbers of animals are in a better position to do strategic and applied research that is not possible in traditional herds. Examples of such work are genetic typing and improvement for the desired production traits and the relationship between physiological parameters and productivity, but the small numbers of camels on most research farms/stations mean that progress in camel genetic improvement will be slow.

Very useful work has been done on the relations between work and certain physiological parameters (Figure 21). In terms of reproductive performance, age at first service was reduced from 1390 ± 36 days during 1961-85 to 1109 ± 36 days in 1986-90 in part due to selection for the character and in part due to better management. Age at first calving was reduced from about 5 to 4 years and calving intervals were shortened by about 8%. Heritability estimates have been obtained for these traits and for those related to weight and these can be used to achieve further rapid gains. Dr. R.T. Wilson (1998) has given a very pertinent suggestion about research, "The danger with camel research on station, as also with other species, is that it often provides intellectual satisfaction to the scientist but does little to improve the lot of camels and their owners in the real world. Care must

always be taken to ensure that research is relevant to real problems. These are best identified in collaboration with owners and herders. Research should also be capable of achieving wide impact after suitable adaptive trials in traditional herds and the technology should be rapidly transferred to these herds so that early productivity gains can be of direct benefit to the people.

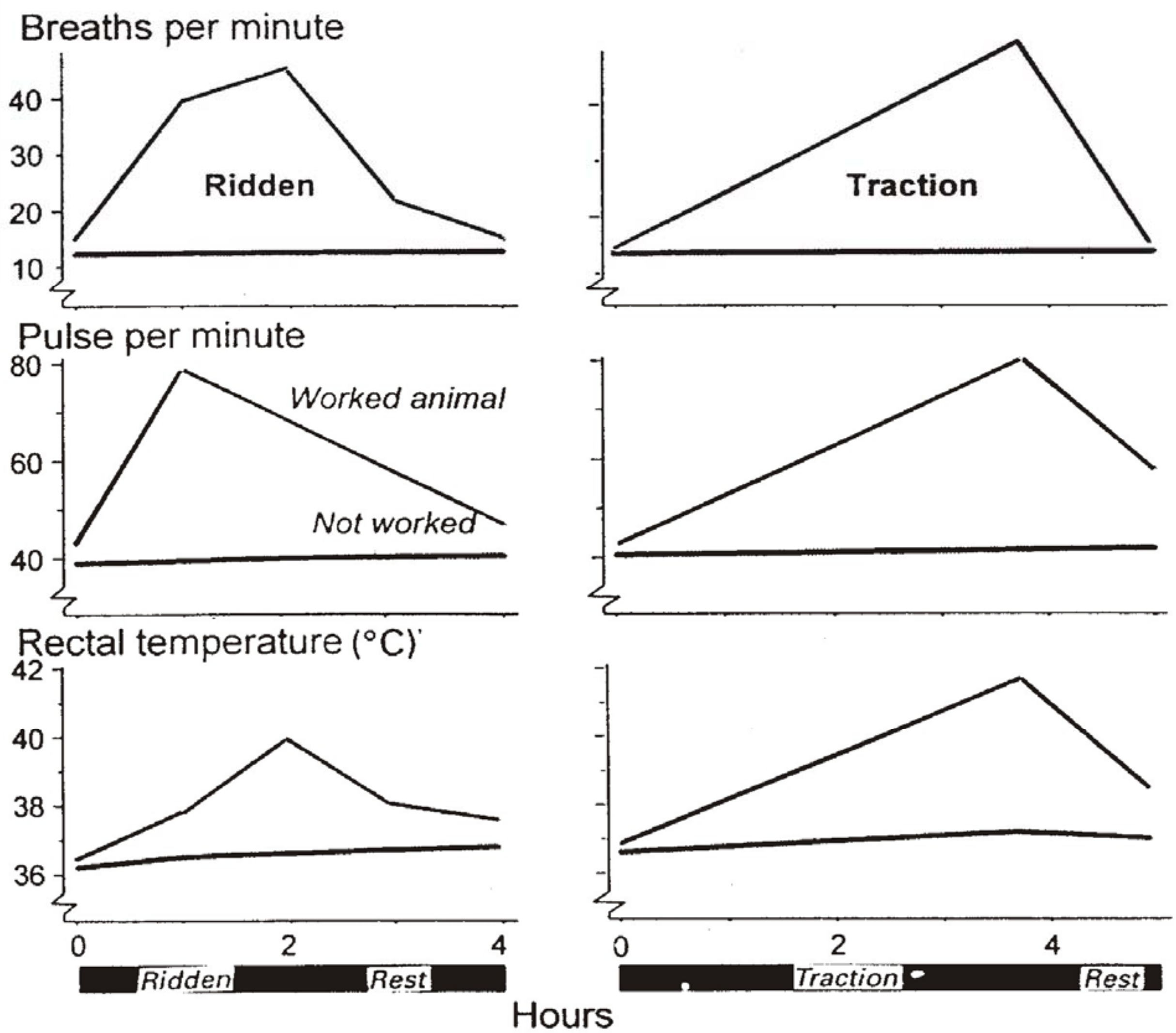

Fig. 21. Physiological parameters of camels subject to work in India
Source: Wilson (1998).

ADAPTATION TO HOT ARID ENVIRONMENT

Q. What is the most significant aspect of camel adaptation?

The ability of the dromedary to adapt to extreme aridity of the habitat is unique amongst large herbivores. The most significant aspect of this adaptation is economic use of water in almost all metabolic functions. The metabolic functions fall into two major categories, the intermediary metabolism and the maintenance of body temperature. Along with physiological mechanisms, behavioural and anatomical adaptations also play their role.

Q. Under natural conditions or on unrestricted rangeland what are the preferred browsing times of the camel?

The camel has preference for feeding at night, in the early morning or late evening or when the sky is clouded or just before and just after sunset. At very hot times camels tend to avoid feeding around midday. Under restricted herding conditions where camels are confined at night, behaviour cannot be described as natural since nutritional requirements have to be met in a shortened period and rumination and rest take place for the most part during the hours of darkness.

Q. Give a few concrete examples of the camel's behavioural adaptations to hot environment.

If the camel is allowed to feed at night, it settles on the ground early in the morning before the sun has warmed the ground, thus reducing heat absorption by conduction from the earth to its body. Further, it tucks both its fore and hind legs beneath it to reduce contact with the ground, unlike buffalo and cattle, which lie in closer contact with the ground (Figure 22). This method of couching eliminates yet another conductance path. Standing or sitting, the camel gradually keeps shifting its position throughout the day to keep in line with the sun, thus reducing the area subject to direct radiation.

When herded in groups and allowed to rest, camels invariably cluster together if conditions are hot, which again reduces the total area subject to radiation. Sheep also adopt this strategy under hot conditions, but unlike sheep which cluster with their heads central to the unit, camels prefer to orient (as they do as individuals) to the sun and move position as the earth rotates.

Q. What anatomical advantages favour the camel to adapt to hot environment?

The large size of the camel is an evident advantage to it to adapt to hot conditions, allowing a smaller relative surface area to total body mass. The relationships of body weight to energy expenditure and the required water loss to preserve a constant body temperature are well known, with heavier weights providing enormous advantages. The long thin legs and neck of the camel are further adaptations to desert conditions, as is the hump. Fat concentrated in the hump and not distributed over the whole body surface allows rapid dissipation of heat through the skin when required. The large pad-like feet of

the camel reduce ground pressure when walking and allow easy progress over sandy surfaces. The massive supra-orbital processes protect the eye from the direct rays of sun. The split upper lip, which is very prehensile and mobile, allows the camel to select the most succulent and nutritious feed portions from the total on offer.

Q. How does the body temperature fluctuation enable the camel to adapt to hot arid environment?

A major physiological adaptation of the camel is its ability to allow its body temperature to fluctuate. The normal diurnal variation in a fully hydrated camel does not exceed 2°C and is in the range of about 36 to 38°C. In a 500 kg animal the heat stored as a result of diurnal variation of this order would be about 4.2×10^6 (joules). In dehydrated camels, when considerations of energy and water conservation become more important, temperature variation can be as much as 8°C in the range of 34 to 42°C, but a more normal range is 6°C from 35 to 41°C. These extremes are outside the range of comfort of most mammals and would be lethal for many. There is a much wider variation in temperature in the camel than in the donkey or in man. A temperature range of 6°C in a 500 kg camel enables 1.26×10^7 J of energy to be stored, equivalent to the conservation of about 6 litres of water if sweat had to be used to dissipate the same amount of heat.

A reduced temperature gradient between the camel and its immediate environment assists further in reducing heat gain as the gain is proportional to the gradient. Heat stored during the day is dissipated to the environment when ambient temperatures are cooler at night. The combined strategies of a high body temperature during the day and heat loss at night allow the water required to maintain a temperature within the acceptable range for the camel to be reduced from 4.7% to 1.4% of the body water pool.

Q. Write a note on thyroid activity in a fully hydrated and dehydrated camel.

In the fully watered camel thyroid activity is higher in summer than in winter, but activity is reduced in camels deprived of water. The decline in activity is important because the generation of metabolic heat is reduced and respiratory water losses are also reduced. Chronic exposure to heat results in depressed thyroid activity as well as reduced plasma, cortisol and growth hormone concentrations and turnover rates. All three sources normally create heat and act in cooperation, so the net result of habituation to heat is some reduction in metabolic rate (Wilson, 1998).

Q. For evaporative cooling which of the two methods is better: an increased respiratory rate or by sweating?

At very high temperatures and constant heat loads even camels need to dissipate heat. Many mammals achieve evaporative cooling through an increased respiratory rate rather than by sweating. Respiratory cooling is relatively more expensive in water than is sweating since faster respiration rates result in more energy being used. Normal respiratory rates in camels are in the range of 6 to 11 breaths/min. (average 8) in the Sahara. Under heat stress these increase to levels of 8 to 18 (average 16). Such low respiration rates do not result in significantly increased evaporation.

Camels avoid expending more energy than necessary when they need to use water for cooling, by sweating. There are about 200 sweat glands per square centimeter on camels, about one-quarter of the number found on cattle. Camels do not sweat continuously as do

many other mammals and sweat evaporates directly from the skin. The latent heat of evaporation is therefore taken from the skin, which is relatively more efficient in losing heat than if evaporation is from the coat surface as it is in many other mammals.

The endogenous heat of metabolism can account for as much as 30% of the total heat load on animal. Camels do not lose appetite to the same extent as other species under heat stress and dehydration. Reductions in feed intake and feeding activities, which may be up to 90% of day-time activity of wild and domestic ruminants could, however, lead to a reduction of total heat load from 10 to 20% (Wilson, 1998)).

Q. Discuss in detail dehydration tolerance, efficiency of use of water and capacity of camel to drink water.

A reduced water supply can be tolerated by a number of species of desert-adapted animals and under these conditions its use becomes more efficient. Efficiency of use and dehydration tolerance vary among species. Among domestic animals kept under the same conditions, cattle lose water three times faster than camels (equivalent to 6.1% of body weight per day at day/night temperatures of 40°C/25°C) and sheep two to two and a half times faster (4 to 5% of body weight). Bedouin goats are capable of sustaining reductions in body weight up to 35% but lose water much more rapidly than camels. Cattle die in four days at a total weight loss of 28%, sheep in about seven days and camels would survive for 15 or more days, mainly because camels do not lose appetite with dehydration. In the real life situation, camels do survive long periods without access to free water. Generally quoted figures, however, are four to five days.

Under free ranging conditions, the frequency of drinking water by camel depends on a number of factors such as the ambient temperature, the water content of the feed and the physiological status of the animal. Lactating females obviously require more water than dry cows, bulls or castrates. It is said that throughout the winter period, camels may not have access to free water. There is an historial record held by camels in Sudan where it was noted 86 years ago that a large herd of camels at a well on May 11, 1917 were drinking free water for the first time since October of the previous year. Water intake is related to the period of deprivation. After long periods of dehydration camels can rehydrate extremely rapidly. As much as 25 to 30% of body weight can be taken in. Some scientists consider that camels drink, immediately, that amount of water required to replace the lost volume but others are of the opinion that they imbibe only about 60% of the lost volume at the first opportunity. There is a record of a camel who drank in 24 hours 186 litres in two separate bouts of 94 and 92 litres after a period of five days without water.

Q. Name the major sources of water loss in camel and compare the same with cattle.

The sources of water loss for camel are about 50% from the alimentary tract and intercellular spaces and 50% from the interstitial spaces, with very little change in the water content of body solids and plasma. In cattle, losses are about equally divided on the one hand amongst the body solids, the alimentary tract and intercellular spaces, and on the other hand between the interstitial spaces and plasma. Animals that are fully watered usually contain about 16% of the body water pool in plasma. Following dehydration

cattle lose about 20% plasma volume. A major part of the camel's ability to withstand water deprivation arises from its ability preferentially to conserve plasma volume, which is reduced only by 5% under severe dehydration. The volume is maintained by absorption of water from the alimentary tact where a reduction of nearly 82% may take place.
Even if there is some reduction in plasma volume in camels, there is no rise in packed cell volume. This is largely due to the peculiar resilience of camel RBC's which contract if plasma volume is reduced but are then capable of reverting to their original size and shape even after severe compression. Camel erythrocytes are more resilient than those of any other animal yet examined.

Q. What is meant by 'attraction of water' to maintain plasma volume?

When plasma volumes are maintained at or near normal levels, turgidity of the blood does not occur and the heart can continue to pump blood to the body surface and extremities, thus assisting heat dissipation and avoiding potential 'explosive heat death'. Other factors, which play a role in maintaining plasma volume are connected with the attraction of water. Glucose levels rise on dehydration, resulting in hyperglycaemia; the hygroscopic glucose then attracts water to the blood. Like glucose, urea is also hygroscopic and its reabsorption into the blood acts as an additional water transfer agent.
Prolactin and oxytocin, normally associated with release of milk (and therefore concerned indirectly with water requirements), are possibly also implicated directly in absorption and conservation of water.

Q. What do you understand by rehydration? Discuss briefly.

Rehydration consists not only of the ingestion of water but also of its absorption and distribution throughout the body tissues. Because of large buffering capacity of their alimentary tract, ruminants are able to drink large quantities of water in a very short time after a period of privation. Animals without this capacity are rarely able to take all their requirements in one short session, mainly due to the problems associated with haemolysis. Some non-ruminants are, however, capable of rapid drinking, including dogs and donkeys. Even amongst the group of ruminants, which drinks rapidly, the camel is peculiar in being capable of absorbing all the water almost immediately into the bloodstream. After four hours water is in equilibrium throughout most of the body tissues and normal intake resumes if water is available. Kidney function has also returned to normal after four hours and the erythrocytes return to their normal size and shape (Wilson, 1998).

Q. What is one of the most salient effects of dehydration on metabolism?

One of the earliest and most important effects of dehydration on metabolism is a reduced feed intake. Even when feed is in abundance, a reduction in water intake depresses the amount of feed eaten. Possibly there are two principal causes for less feed being ingested. One involves a reduction in the flow of saliva from the parotid glands and the other relates to changes in the rumen flora leading to less efficient digestion, particularly of nitrogen.

Q. Why is it so that feed intake in camel does not decline due to dehydration?

In contrast to most species, the feed intake of camels does not decline markedly following dehydration (nor does that of the arid-adapted donkey). This is one of the

major reasons whey camel is so widespread and relatively so productive in extremely dry areas. In the camel under normal conditions of full water status, there is a rapid and copious flow of serous saliva amounting to about 21 litres/day per parotid gland. Using normal ratios of parotid to total salivary flow would indicate that the camel produces about 80 liters/day when fully watered, this being reduced by 80% to about 16 litres/day when dehydrated. It appears that this amount of saliva is sufficient to maintain the appetite of camels under severe dehydration.

Q. What factors govern the rates of water turnover in arid-adapted ruminants?

Low rates of water turnover are a characteristic of arid-adapted ruminants. They allow longer times between drinking and thus enable better use to be made of sparse desert vegetation. Low water turnover rates in heat-stressed and dehydrated animals are associated with a reduced metabolic rate under these conditions. The two most significant factors contributing to water turnover in animals at maintenance or under low production levels, are the requirements for evaporative cooling and the need to ensure an adequate feed intake. Lactating camels use water at rates that are almost 50% higher than by dry animals. Turnover rates are also increased for animals carrying heavy loads. These also vary with environmental conditions. Water availability in different seasons and species of animals also influence turnover rates. Rates of water consumption in camels were only 34 to 70% of those of other species and did not differ between dry and wet seasons. In donkeys too, the rates of consumption did not differ between seasons, but sheep (53%), goats (77%) and cattle (94%) drank much more in the wet season than in dry (Figure 23). Goats and sheep drank larger volumes at each drinking but were watered less frequently. In hot weather fully watered, sedentary camels take in less water per unit of body weight than do sheep, horses or cattle. Physiological adaptations enable dehydrated camels to conserve water by reducing all pathways through which water is lost. Camels deprived of water in 42°C environmental temperature lose about 2% body weight per day (about half that of Merino sheep under the same conditions. It has been estimated that baggage camels working in the heat of the day have a water turnover of only 3.4 litres per 100 kg body weight. The camel, in fact, has the lowest water turnover rate of all the desert ruminants, and the most other environmentally adapted animals as well (Wilson, 1998).

Q. Write a note on water balance in the dromedary.

The dromedary's water intake is through drinking and the water in the feed. The need for drinking depends on environmental temperature and humidity and the water content of the feed. Under range conditions if water is readily available, camels may drink daily or may not for several days. The main water losses are from evaporative cooling of the skin, in urine and faeces, and even in these functions the conservation of water can be very efficient. During exercise physiology studies, obvious sweating was not observed. It was concluded that the main cooling mechanism was from respiratory losses. The experiments were conducted on a tread mill in a room cooled to about 23°C.

The total body water in the camel as reported by Australian workers is between 65 and 75%. Indian workers reported a figure of 63% in the summer and 59% in the winter. They also established compartmentalization of the water as follows:

	Summer	Winter
Intracellular water (%)	45.5	42.5
Extracelular water (%)	16.5	16.3
Interstitial water (%)	8.9	10.0
Blood volume	7.8	6.4
Plasma volume	4.7	3.8

The summer/winter difference in plasma volume may be related to the regularly observed summer fall in red blood cell values and total protein. In a fully dehydrated camel with 65% body water, alimentary water has been reported as 12%, which is similar to the figure for tropical cattle. The total water content of the camel is considerably greater in hot dry weather (up to 75%) than in cooler periods (down to 50%), which indicates its physiological water conserving capability. It is well established that the glandular sac area in the rumen secretes water into the alimentary compartment. This fluid is relatively rich in sodium, potassium and probably bicarbonate too.

Q. Give a list of the factors that enable the camel to withstand prolonged water deprivation.

The ability of the camel to store water in the body is a myth, rather its ability to conserve water and use it very efficiently is outstanding. If 28 to 32% loss of body weight due to dehydration is regarded as the critical point, buffalo/cattle will die after about 4 days without water, sheep after 6 to 7 days and camels after 15 days or more. The factors that help enable the camel to tolerate such an evident water deprivation are listed below:

- Formation of dry faeces (45% water) results in a loss of only 0.5 litre of faecal water per day.
- Ability of the kidneys to concentrate urine and reduce its production.
- Reduction of saliva flow.
- Large volume of water held in the alimentary tract (12 to 20% of body weight).
- Ability to recycle water from blood to forestomachs helps preserve appetite thus the animal keeps getting all possible water from blood.
- Sweating instead of panting saves both energy and water. Respiratory rate may actually be reduced by reduction of activity and metabolic rate during hot weather.
- Allowing body temperature to rise and fall with the environmental temperature can save 4 to 5 litres of water daily.

It is sometimes necessary to utilize the camel’s ability to travel without water for several days through an arid country. It is best if the camels are preconditioned to water deprivation beforehand. It is done by withholding water for progressively longer periods before such a trip starts.

Q. Do you think water metabolism and water of metabolism are one and the same? Discuss briefly.

Over a period of 2 to 3 weeks, camels can lose 32% of their body water without serious consequences. Humans and many other mammals are in serious trouble at just over 10%

loss. Changes in water metabolism occur in the dehydrated camel. Injection of tritiated water has shown equilibrium time to be 8 hours in the watered camel and 12 to 24 hours in the dehydrated camel. For the first two days of dehydration, the rate of tritium dissipation from the blood is the same as when fully watered. For the next 8 days, only a total of 7% of the tritium had gone. This indicates the efficiency with which the camel can preserve body water during scarcity.

In the past it has been postulated that the metabolism of hump fat could supply water to the fluid compartments when the camel is water deprived. While water is a by-product of carbohydrate and fat metabolism, it is now known that the act of gaining the oxygen required would cause the loss of more water than would be gained. Also, cellular metabolism creates heat and the camel's survival strategy, especially during periods of water deprivation, is to reduce metabolic rate and hence heat production and water loss. Experimentally, camels have been water deprived until 30% of body weight has been lost. Height, length and circumference measurements of the hump taken before and after showed no change. For these reasons the hump cannot be regarded as an important potential water source.

Q. What mechanisms help the camel to avoid water loss through respiratory evaporation?

Many animals respond to a hot environment by resorting to an increased respiration rate and in some cases to open-mouth panting. Respiration rates in the camel increase very little with increase in ambient heat load and the respiratory route, probably, is a very minor source of water loss. In addition, camels are able to exhale unsaturated air under some conditions. The combination of cooling and desaturation can result in saving 60% of the water that would be present in fully saturated air exhaled at body temperature. A lower rate of breathing at night also increases the tidal volume of air and the amount of oxygen extracted, thus further reducing water loss. The only other large animal which has been recorded as being able to expire unsaturated air is the ostrich, although the phenomenon is well known in small rodents.

Q. Write a note on cutaneous evaporation in one-humped camel.

Some water moves through the skin of mammals by insensitive diffusion. Most of the water, which passes through the skin, however, does so in the form of active sweating. Larger mammals usually sweat to dissipate heat. Among the domestic species, both camels and cattle have adopted this mechanism. A characteristic of the camel is that there is no copious flow of sweat or obvious wetting of the hair. The evaporation takes place at the surface of the skin and not at the extremities of the hair. The latent heat of evaporation is therefore drawn from the skin rather than from the atmosphere.

Q. Write a note on loss of water in camel faeces.

When ample water is available and animals are not dehydrated, a great deal of water is excreted with the faeces. The total amount of faeces and their water content vary with the type of feed and its digestibility. Ruminants are able to extract considerable amounts of water from the intestinal contents but this process is much more efficient in arid-adapted animals when dehydrated. All the major species of domestic ruminants are able to reabsorb a greater proportion of gastrointestinal water when dehydrated, while at the

same time increasing the concentration of electrolytes in the retained fluid. The overall response to dehydration by ruminants is a reduction of between 10 to 35% of faecal water, the camel being among the most efficient (Table 19).

Table 19. Water contents of faeces of domestic ruminants when fully watered and when dehydrated

Animal species	Water content (g water/100 g dry matter)		
	Animals fully watered	**Animals dehydrated**	**Percentage decrease**
Camel	109	76	38
Camel	268	168	38
Temperate cattle	362	302	17
Goat	140	88	37
Goat	132	106	20
Sheep	134	93	31

Source: Wilson (1989).

Table 20. Total urine volume and solute concentration in domestic ruminants when fully watered and when dehydrated

Livestock species	Urine volume (litres/100 kg liveweight/day		% change	Urine osmolarity (mOsm/litre)		% change
	Hydrated	**Dehydrated**		**Hydrated**	**Dehydrated**	
Camel	0.29	0.07	76	1473	2230	51
Camel	-	-	-	620	2100	239
Temperate steer	0.98	0.72	27	855	1043	22
E. African goat	0.70	0.40	43	895	1425	59
Barmer goat	2.52	0.51	76	-	-	-
Bedouin goat	1.71	-	-	1315	1771	35
Marwari sheep	1.49	0.73	51	-	-	-
E. African sheep	0.80	0.20	75	-	-	-

Source: Wilson (1989).

In most ruminants loss of water in the faeces represents a considerably lesser proportion of total water loss than does evaporative cooling. Faeces with low water content are characteristically formed as pellets and even the usually large cakes of dung produced by cattle occasionally assume this form under conditions of severe dehydration.

Q. What is the role of kidneys in dehydrated camels?

The ability of the mammalian kidney to concentrate urine is an important factor contributing to survival in arid lands. The low urine volumes normally voided by the camel are reduced further under dehydration and a relatively high total osmolarity (i.e. the concentration of solutes) is further increased (Table 22). In relation to its body weight the camel passes very little urine, even when it has free access to water, and the total amount rarely exceeds five litres/day. In addition, the camel has another peculiarity i.e. it urinates frequently, a small volume each time, indicating that the camel bladder is very small. In both sexes a rhythmic release of the sphincter muscle empties the bladder of urine in a series of small jets, the whole process taking a considerable time. The camel's habit of urinating on its legs is an additional adaptation to the desert, as it does cause some evaporative cooling.

It has been shown that under dehydration the function of camel kidneys is depressed, including a reduction in glomerular filtration rate from about 60 ml/100kg/min to 15 ml/100kg/min. When camels are allowed to drink immediately to satiation, the kidney function rapidly returns to normal. Within half an hour there is a significant increase in the urine flow rate, glomerular filtration rate and in kidney plasma flow, which are accompanied by significant decreases in plasma and urine osmolarities.

Q. How is it that dehydrated camels produce diluted milk?

As a result of adaptation to desert conditions, camels acquire the ability to produce diluted milk. This involves the production of milk with a higher water content when the animal is dehydrated than when it is fully watered. They do this by withdrawing water preferentially from the intestines under the action of prolactin and oxytocin. The ability to dilute milk under similar conditions of water stress has also been demonstrated in women and in cows. Milk dilution is not known in other mammals. Dilution of milk involves reductions of fat, lactose, protein, calcium and magnesium but increases in sodium, phosphorus, phosphate and chloride, with no changes in urea levels. The dilution of milk under dehydration could be a physiological adaptation to ensure an adequate supply of water to young animals with access to no other source while at the same time continuing to provide them with an adequate supply of other nutrients.

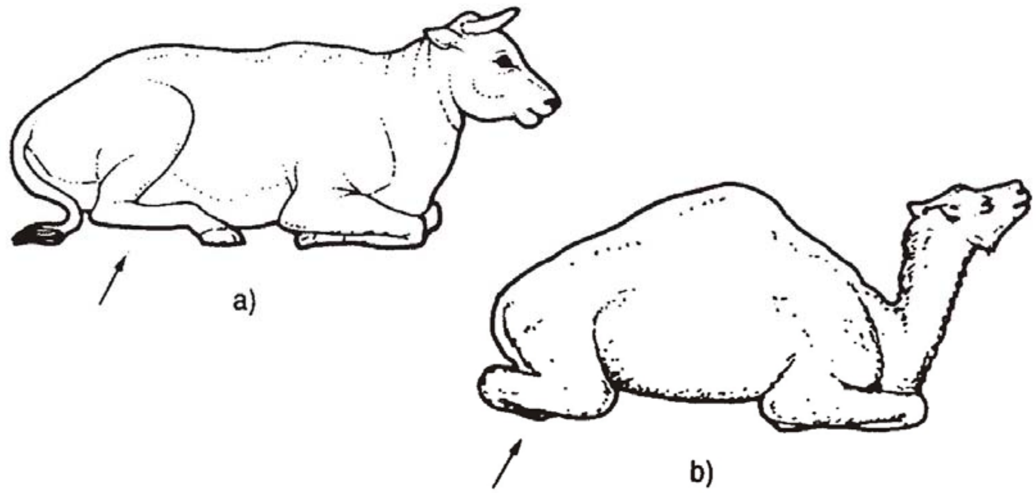

Fig. 22. Lying and couching postures of a) cattle and b) camel
Source: Wilson (1998).

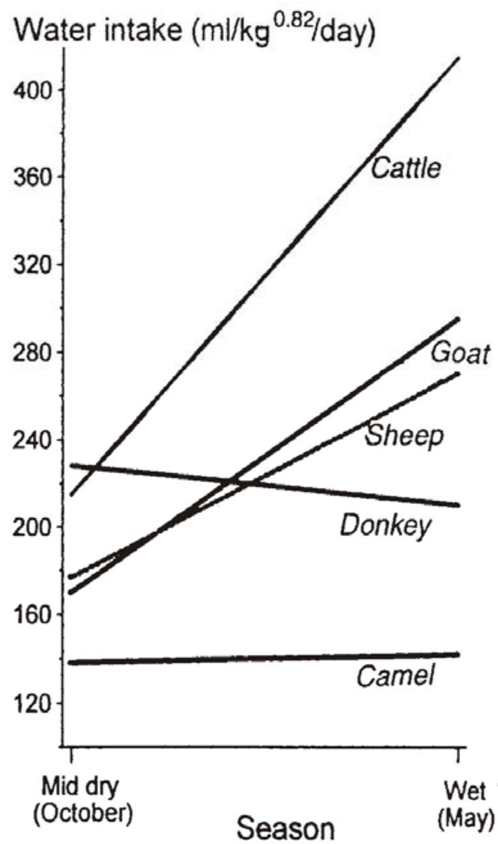

Fig. 23. Water consumption by various species of domestic livestock in Turkana, Kenya
Source: Coppock *et al*. (1988).

MANAGEMENT PRACTICES

Q. Is there any relationship between watering management and grazing pressure? If so, discuss.

The ability of camels to go for varying periods of time without water is a major factor in placing the family camp and camel herd in relation to sources of water. This ability is affected by several factors such as how much work (including walking in search of its feed) the camel has to do and the ambient temperature. Camels spend more energy (involving the use of water for evaporative cooling) at high temperatures, increasing thus the need for water and reducing the time between waterings. The management implications of this are that camels should be provided with shade, probably the best, cheapest and the easiest is natural shade under trees. As an alternate or in addition, they should be grazed at night and rested during the day.

If camels and other stock can be based far away from a water source, the total area available for grazing is greatly increased, the stocking rate can be lowered and the dangers of environmental degradation are reduced. In simple terms, a doubling of the interval between successive visits to water results in a four-fold increase in the area available for pasture, with a corresponding reduction in grazing pressure. More especially, the time period between successive waterings has an important bearing on the carrying capacity and the degradation risk of a given area. If for example, the number of animals remains the same, the stocking rate increases eleven-fold if the watering interval is decreased from ten to three days. This is because the potential total grazing area around one water point, assuming a maximum distance walked of 30 km/day is reduced from 70500 km^2 to 6360 km^2. The number of camels owned by a household is a further factor in the equation that includes grazing and land use in terms of water for people. Families with many camels can afford to use them to transport water for their own use. The benefits of this management strategy not only reduce the pressure on the grazing resource but also free women and girls (who usually perform the chore) from the drudgery of the daily carrying of water. However, freedom from carrying the water from the water source might deprive the women of social contact with each other and of an occasion to exchange ideas.

Q. Discuss the requirements of camel for water under different conditions.

In most areas in Asia and Africa where camels are kept, permanent surface water such as rivers and lakes, springs and artesian wells, is rare. During the rainy season, many temporary streams, pools and man made reservoirs (called Tobas in Pakistan) fill up. All livestock including camels find all the drinking water there. In addition, fresh green forage is available after rains, which provides the camel adequate water. In areas where adequate watering points exist, the usual watering interval for camels is three to four days. Watering intervals of five to seven days are still considered normal. Intervals longer than seven days constitute a stress on the camel. Camels being used in irrigated areas and those pulling carts in cities are watered almost daily.

During dry seasons when the surface water disappears and the vegetation dries up, camels have to be watered from subterranean sources such as man made water holes, old wells etc. In highly arid areas as in Eastern Africa, watering camels in dry season is a very time consuming and arduous job since water has to be lifted bucket by bucket from several metres deep wells. However, in various countries, state agencies are providing more water-holes, deep bore holes (tube wells) with motor or wind driven pumps and supply of water through large tankers when there is a prolonged drought. Camel herders also move to surrounding irrigated areas during dry spells.

Water requirements of camels, although low in comparison to other livestock species, are still quite high in absolute terms. At the height of the dry season, when the ambient temperatures are high and the vegetation is dry, an adult camel needs approximately 80 to 100 litres of water every five to seven days. If the pasture consists mainly of halophytic plants and/or the available water is rich in minerals, the requirement will increase. It will also increase in lactating animals. A herd of 100 camels during the dry season might require as much as 10,000 litres of water three times in the course of two weeks. Wilson (1988) reported that under normal conditions in Libya, camels watered at 3-day intervals consumed about 15 litres per day in winter and 55 litres per day in height of summer. Labour needs for watering have perhaps been one of the major factors affecting camel herd size and expansion in parts of Africa and Asia in the past.

Q. Write a note on milk suckling from the dam by the camel calf.

With most of the pastoralists sex of the calf determines the amount of milk the calf would be allowed to suckle from its dam. In case of female calf, mostly only two teats are milked and the rest is used by the calf. However, the male calf is either allowed to suckle only one teat or allowed to suckle only when all the milk has been removed from the udder. When male camels have no market either for riding, racing or for slaughter or breeding, under these conditions they may be starved to death to obtain more milk for human consumption or for sale.

The standard routine is to separate the calves from their mothers during day and night and leave them together only for short periods after milking. To achieve this calves are kept in separate night enclosures and are herded separately during the day. Another widespread system, practised by herders is to allow the calf to follow their mothers during the day, but to tie some or all of the teats with some soft bark to prevent suckling. In improved system of management, an udder basket or net serves the purpose. Muzzling the calf during night time has the same effect as keeping it in a separate enclosure. It cannot be used during the day since it would prevent the calf from grazing.

Q. What type of restraining is required to check the camel from kicking or biting during milking?

Milking camels are generally very docile which accept handling and milking with ease. In the first lactation mainly there may be cases of anxiety or aggressiveness, which require a mild form of restraint to facilitate milking. One of the simplest is to close one foreleg on itself usually the right one i.e. tying the fetlock to the forearm to unbalance the camel should it try to kick. In a variation of this technique one foreleg can be tied to the other, fetlock to carpal joint, which has the same unbalancing effect. If the animal is more

aggressive, habitually trying to bite the milker, in addition to tying a foreleg, holes are pierced through both the ears and wooden plugs are suspended by short strings from the ears. With each quick movement of the head, the pendulous plugs keep hitting the camel in the face disorienting it. The animals learn fast and the device can be removed after a few days. As an alternate a muzzle made locally in the form of net using camel hair, can be put on camel's mouth. Some camels are particularly prone to kicking when they are milked. In this case the rear legs are tied (hindleg hobble) tightly well above the hocks or a stick is tied across both rear legs just over and behind the hocks.

Q. What measures would you adopt when a camel refuses to nurse its calf?

First determine that the refusal to calf is not due to a painful condition of the udder. Camels, especially first calvers, quite often refuse to nurse their calves. When this happens they must be forced to accept their young, otherwise milk production would cease within days. Camel raisers have developed several devices to force the mothers to accept their young, all based on the same principle. All these techniques aim at causing increasing degree of discomfort or pain to the mother, which will divert her attention to such an extent that she will 'forget' to reject the calf. After the calf has sucked a few times, the device is removed and in most cases the relief is so soothing that the mother will accept the calf permanently.

In case a mother only mildly refuses to suckle the calf by moving away whenever the calf approaches, one front foot is bent on itself by flexing the fetlock so that the leg must support the weight on the extremity of the metacarpus. The device is kept on during grazing time and removed at night. The position is quite uncomfortable, since the camel cannot walk properly or sit down. In more aggressive cases, the nasal septum of the mother is pierced; a thin rope is passed through the perforated nasal septum. The rope is then tied to a tree in a way that the head is pulled forward and upward at the same time. The camel stays tied for several hours, which is usually enough because the position appears to be extremely uncomfortable to the camel. The calf, which is tied to the same tree, most probably, can now suckle without any interference (Schwartz and Dioli, 1992).

Q. If the mother is not only persistent in refusing the calf, but is also openly aggressive and biting or kicking it, what appropriate measure needs to be adopted that the calf is accepted by the mother?

In such cases a widely used technique by Somali herders, locally called 'Qallah' is the last remedy for this behaviour. The technique aims at simulating pre-parturition pain. The anus of the camel is closed mechanically that it cannot defaecate or urinate. The perineal device consists of two sticks, usually made of acacia wood, flattened on one side and indented at the ends to facilitate tying. The perineum including the anus is grasped and stretched and the sticks are placed above and below and tied with a string, which is passed around several times and secured at the end of the sticks. The anus and vulva are tightly closed preventing the passing of faeces and urine. At the same time soft bark fibres are tightly placed over the nostrils. Due to nearly complete closure of the nostrils, the camel is forced to open mouth breathing causing acute discomfort to the animal. The discomfort produced by the two devices and the intense abdominal pain caused by the closure of the anus and vulva become so severe and sufficient to distract the animal from

aggressive behaviour against the calf. Often the acceptance of the calf is permanent. The maximum time that the perineal device can be kept on is probably 8 to 10 hours, but the procedure can be repeated. The perineal device, of course, is a simple aid in getting the calf accepted by the dam, but it seems to have an aspect of cruelty on the animal, therefore, it may be used only as a last resort (Schwartz and Dioli, 1992).

Q. Suggest a few practicable measures to make the camel release its held up milk.

In problem buffaloes and cows, the use of oxytocin is common for let-down of milk. There is every likelihood that oxytocin would be equally effective in camel for the let-down of milk. However, if the camel is still refusing to release the milk, only the perineal device without closing the nostrils might work, or closing the nostrils as described above, without resorting to anal closure might be used with good success.

Q. Write a note on weaning of camel calves and give a brief outline of two weaning methods.

Camel calves are usually weaned at the age of 6 to 12 months. When milk is in abundant supply or demand is low, the herders do not interfere and calves suckle milk until their mothers dry up, which might be as long as 18 to 20 months. Such a long weaning period is not commensurate with modern husbandry practices. Prolonged weaning no doubt delays next breeding. Thus it seems more desirable to wean the calves at the age of 6 months. Normally there is still competition for the milk between the calf and herder and weaning is done when the calves intake of forage is sufficient to sustain. The easiest way of weaning is to transfer the calf to a different herd. Since this is not always possible, therefore, other weaning techniques were developed.

Thorn Method: Large and sharp thorns are pushed through the upper lips of the calf from the inner side and fixed in place with acacia resin. If the calf now tries to suckle, it will prick the dam’s udder and thus will be kicked away. The thorns can be removed after about 10 days.

Tying Upper Lip: Tying the prehensile parts of the split upper lip with a thin string in a figure of eight knot, making it impossible for the calf to keep a hold on the teat. With these techniques weaning can be achieved within a few days. There are other methods such as to partially cut a small skin flap from the nose of the calf and tie this in an upright position with bark fibres, the other is to separate a thin strip of the dorsal mucosa from the tongue muscle. These methods make suckling painful for the calf. These methods are more painful as well as involve an element of cruelty and, therefore, better not be practised (Schwartz and Dioli, 1992).

Restraining Methods

Q. Describe briefly the methods commonly used for restraining camels.

Well handled camels are always friendly and docile and they may be even affectionate to those whom they known well. However, there are occasions when they need to be restrained and immobilized. This can be best done quietly but with determination and without any physical abuse. Many camels can be controlled with minimal effort, using a simple rope halter or just the manual lip twitch or a stick twitch. The lip twitch is used manually to apply moderate pressure. The lips being very sensitive help in controlling the

head. One person can hold the upper and lower lips separately in both hands and keep them stretched. The stick twitch is preferably used on one lip. A quick and efficient way to restrain calves and immatures which are not too heavy, for purposes of brief inspection/examination, drenching or injections, is to grasp them by the tail and the lower neck, virtually hugging them to ones chest. Slightly larger animals can effectively be held for a few minutes by grasping the tail and one hindleg just above the hock. Brief physical examinations and application of drugs can be done this way.

Adult animals can be controlled and guided with a rope halter in most situations. Should it be necessary to keep an animal from moving fast, it is a common practice to tie one leg to itself (fetlock to forearm or fetlock is flexed and tied). The animal can still move around over considerable distance and feed. For longer or painful treatments such as branding or castration, it is necessary to immobilize a camel in recumbent position. It can be done by limiting the neck movement and the animal is kept sitting by a tight rope leading around the flexed forelegs and over the neck or the animal is secured and tied in sternal recumbeney. It might still be required to restrain the head, which can be done by the manual lip twitch or by a rope twitch, which can be fixed securely behind the lower canines.

To keep a rutting bull from fighting other males and from wandering off in search of females in other herds, his forelegs are tied together with a short rope just above the fetlocks, efficiently restricting him to very short strides. Sometimes the ankle ropes are secured to the ground to further restrict the movements of the animal. In another method used by African tribesmen, a tight rope collar slightly constricts blood flow in jugular vein and creates a slight discomfort. If the bull tries to engage in any strenuous activity, blood flow and breathing become rapidly impaired due to the tourniquet placed around the bull’s neck and the animal is forced to calm down immediately. Grazing and other activities are not hindered at all by this device.

Q. Discuss the various methods of restraining camels.

From among the various restraining methods which one to use depends on the treatment, the camel’s training and temperament and its relationship with its handler. Some of the common methods are given below:

A well trained camel needs to be restrained only by holding its head rope or nose-peg. If directed to lie down it will do so. Restrain a small camel by holding its upper and lower lips with both hands and turning its head to one side. If the camel is somewhat trained and the handler is an experienced person, this should suffice when giving an injection. If necessary a second person can hold the camel by its ears. The same method can be used with a large camel if it is in a sitting position.

Hold the camel’s lower jaw with a rope running behind the front teeth. Hold the rope in your hands; do not tie it to a tree or post, as a sudden movement can break the camel’s jaw.

Make the camel stand on three legs by tying one of its fetlocks to its foreleg with a rope (Figures 24a and b).

To restrain a violent animal, tie a rope around its neck and have two people hold the ends, one on each side of the animal. Make sure the camel does not suffocate (Figure 25).

If the treatment is painful, make the camel lie down by tying one of its fetlocks to its foreleg. Then pull either the other front leg or both hind legs forward with a rope around the fetlocks.

Tie both front legs together with a rope passing over its neck.

To make the animal completely immobile, also tie the hind legs together. Bend the neck to the side by pulling on the head-rope. It is also possible to immobilize a camel by injecting it with a sedative (K. Rollefson *et al*., 2001).

Bleeding–A Strange Practice

Q. Why is bleeding of camels practised by certain groups of people in Africa?

Although bleeding of camels has nothing to do with their management neither it is practised by majority of the camel herders whether in Africa or Asia. It is being discussed here simply to mention that even in this era of civilisation, blood of cattle and camel is consumed fresh or mixed with milk and fermented by some ethnic groups of pastoralists. In Muslim society the intake of blood in any form is prohibited. Mainly younger males and castrate camels are bled. Immature and fertile females are generally excepted. Bleeding is done through a small incision in the jugular vein, which is kept turgid by a tourniquet. An alternative bleeding site is the facial vein. The amount of blood collected at one bleeding varies with size, weight and nutritional status of the animals, 5 to 7 litres are often taken in one bleeding from an adult animal. Animals are commonly bled twice or thrice a year. If the need arises bleeding intervals can be reduced, provided the feed base of the animals is adequate (Schwartz and Dioli, 1992).

Identification

Q. What are the objectives, types and methods of marking camels?

Identification of camels is done with the following objectives:

i) To establish ownership, ii) To check thefts, iii) To certify ownership for trading, iv) To identify animals that go astray, v) to identify the animals during experimentation, and vi) To identify the newborns with their dams. There are two types of marking or identification of animals.

i) Temporary identification as in case of experimental work and to keep identity of newborns with their dams. For temporary identification, plastic tags of different colours may be hung around the neck of the animal using a string or metallic tags with numbers on them may be attached to the ear of the animal.

ii) Permanent marking may be done by three methods:

Camel herds owned by nomads and pastoralists are most of the time located in deserts and arid areas where bound by their traditional system they use hot-iron branding for identification of their animals. Since the use of hot-iron is evidently stressful for the animal therefore its use is now getting out of date. Pastoralists also use branding as a treatment for painful swellings and lameness such as stifle joint swelling, stiffness and musculo-skeletal faults. Branding increases localized blood flow thereby aiding the healing process. Branding appears to improve the condition at least temporarily. While branding the camel, you must be sure that it is done on the lower part of the thigh so that the hide is not damaged.

Q. Describe the methods used for identification of camels, including the most recent ones.

Permanent identification is very important for maintenance of accurate breeding records, especially artificial breeding programmes such as multiple ovulation embryo transfer. It is also important to establish the identity and parentage in systematic breed improvement programmes, to determine the ownership of the camel, and to prevent illegal substitution in racing and while trading the animals.

The skin of the camel takes fire brands very well. Of course, hot iron branding involves cruelty to the animal, yet it is still in vogue in many societies. It leaves a permanent mark on the animal. Branding should be done below the level of thigh to avoid damage to the skin of the animal.

Tattooing numbers or symbols inside the lower lip is also a satisfactory method. Commercially available tattooing sets are suitable for the operation. The mucous membrane of the camel's mouth is grey in colour, thus a tattooing ink other than black (e.g. red)may be necessary to give sufficient contrast. The tattoos should be placed in the pliers so that the tattoo is properly oriented for reading when the camel's lower lip is turned downwards. The animal should be sedated for tattoo application.

For temporary marking, a suitable spray can of pigment or a washable paint, is often used on the side of the neck of the camel.

It is possible to freeze brand camels except the pale-coated animals. The areas to be branded should be very closely clipped or shaved. The brands made of copper are placed into methyl alcohol bath containing dry ice. When bubbles cease to rise from the surface of the brand it is considered cold enough. It is then held on the animal for exactly 30 sec.

In institutional situations, especially those having large herds that are likely to spread around and get mixed, a very good system is to use uniquely numbered transponder implants. These can be implanted into nuchal ligament via a 14 g needle. A suitable site to be prepared as for a surgical procedure by shaving and skin disinfection is about the junction of the center and caudal one-third of the neck. AVID Microchip (AVID, 3179 Hammer Avenue, Norco, CA91760, USA) kits come as a sterile pack of implant, needle and implanter ready for immediate use. A hand held battery powered reader is used to locate the chip and read its 9-digit number at any time subsequent to implantation. With the implant inserted into the nuchal ligament, it is possible to easily locate and read the number from either side of the camel. In calves, implantation may be done shortly after birth, but preferably be done at 10 to 12 weeks age. The transponder chips, no doubt, are a good device for permanent and accurate identification. It is, nevertheless, necessary to have each individual animal restrained to read the identification number, which in some circumstances is inconvenient and affects efficiency of working.

In support of the transponder chips, adjustable plastic neck straps with embossed black numbers registered against implant numbers, and in a range of colours, allow individual camels to be identified visually, even in a group, at a distance of about 15 metres. Occasionally, a strap may be lost, but the identity of such an animal may be reestablished by reading the implant and a new neck strap applied. For proper fitting the strap should

be placed around the cranial part of the neck in such a manner that a clenched fist may still pass through.

Castration

Q. What are the advantages of castrating camels. Give details of the method used for their castration.

Castration of males not required for breeding is an important management tool for most species of domestic animals. Most traditional owners of camels do not castrate their male animals, they probably think that it makes camels weak. There are, however, certain advantages in castrating animals in both traditional and modern herds. Castration prevents the production of male hormones of testes origin and thus eliminates the aggressiveness associated with 'maleness'. Castrated males are therefore easier to manage in physical terms. They can be kept in herd of entire males or in female herds since neither they fight with entire males nor they can cause unwanted or out-of-season pregnancies. Castrated males also usually have better carcass composition than those of entire animals and the taint or smell that is present in meat from older male animals is not a problem (yet to be confirmed). Because male camels attain sexual maturity beyond two years age, thus there is no need to castrate them at a very young age. In this way the more rapid growth of entire male animals is conserved as long as possible.

Some of the methods of castration used in other domestic species are not appropriate for camels. If they are not castrated until they are almost adult then it is clear that elastrator or rubber ring method cannot be used. In addition, because of the arrangement of the scrotum high up between the legs, the fact that it is not distinctly divided into two separate compartments and because of its shape, the burdizzo or bloodless castrator cannot be used either. Surgical removal of the testes is thus the only way that (except by chemical means which are also not appropriate or generally practical in commercial herds) camels can be castrated.

If castration is carried out at two years age or more as recommended, the animal will need to be restrained in a crush or tied down. The camel should also be sedated using a sedative or a combination of sedatives such as a mixture of chlorpromazine (2 mg/kg) + pentazocine (2 mg/kg) appears to be satisfactory for general anaesthesia (better follow the instructions of the manufacturer). A local anaesthesia, following the recommended practice for it, should also be used around the area of the scrotum. The operator and all the equipment he uses, plus the surrounding area, should be clean. The operation is best done on a clean canvas laid out for the purpose. The scrotum itself should be cleaned with alcohol or a disinfectant. One handler should squeeze the front of the scrotum to force the testicles to the back. The other handler should make as small a cut as possible in the back of the scrotum to expose the testicle. The cord leading to the scrotum and the arteries and veins supplying blood to the testicles should then be cut cleanly. The operation is repeated for the second testicle. There is no need to stitch the wound but antiseptic and antibiotic powder should be liberally sprinkled on it. If possible, castrated animals should be kept in clean surroundings including clean pasture and disturbed as little as possible until the wound has healed. They need to be inspected to ensure that the wound does not become infected or attacked by maggot flies. If there is any sign of

infection, remedial action including cleaning the affected tissue again and perhaps injection of a systemic antibiotic may be needed.

Herd Composition

Q. Describe in detail the general trend of composition of camel herds.

Free-ranging Camels: Like buffaloes and cows, camels are herd animals, this probably being one of the factors, which led to their being domesticated. It is not sure what was the most common or typical group size and composition of camels before domestication took place. Nonetheless, an indication may be obtained from Australia where groups of feral camels comprise one adult bull and one to several adult females, subadults and young. Group size averages 9.2 (range 2-21) in these feral camels. Groups were stable but not territorial and had a 'home range' several kilometres square. The social structure of camel herds seems to be rather loose and the inter-animal distance is usually more than it is with cattle, buffaloes, sheep or goats.

Controlled Herd Camels: Traditional camel production systems have often been criticized by scientists and development workers that herds are not managed efficiently in terms of sex and age structure and that there are many unproductive females in the herds and the case is even worst for male animals, very many being retained that are not required to provide an adequate breeding ratio. This conventional wisdom of critics, as applicable to camels is wrong, since it fails to take into account the producers production objectives. These objectives are often multiple and complex and result in a herd composition which is a compromise between the ideal and the practical situation. The final composition of a herd is also influenced by the reproductive performance of the camels and by the climate. In the example given in Figure 26, the composition of the herd, with many mature castrate animals, tends to confirm the important role of males in the transport of goods. It is also possible to calculate the lifetime production of young produced by a breeding female (age at first calving plus interval between parturitions multiplied by number of young equals age at which more females leave the herd) and it is clear there was a drought for 10 years previously as indicated by the 'break' in the pyramid on the female side.

In a similar manner, herd composition for several production systems can be calculated (Table 21). Whatever little information on this aspect is available that tends to show that the slow rate of reproduction and the long generation interval are the factors that have a major bearing on herd composition. These factors result in a proportion of 40 to 45% breeding females in most herds. The role of Somali camel as milk producers is clearly indicated by the high proportion of mature females and very few males in the herd (Wilson, 1998).

Table 21. Composition by age and sex of camel herds in various production systems

Sex and age	Production system					
	Rendille Kenya	Laayoune Morocco	East-central Niger	North Niger	Butana Sudan	Central-south Somalia

Male						
> 4 years	5.2	22.4	21.8	17.1	22.0	
1-4 years	13.9	13.6	8.1	10.3	9.8	1.0
< 1 year		7.1	7.2	8.2	4.8	9.0
Castrate	12.0	n.a.	n.a.	4.8	n.a.	8.0
Total	31.1	43.1	37.1	40.4	36.6	18.0
Female						
> 4 years	55.0	28.2	42.7	38.9	41.4	
1-4 years		13.1	10.7	15.6	14.2	71.0
< 1 years	13.9	13.6	9.4	5.1	7.8	11.0
Total	68.9	54.9	62.8	59.6	63.4	82.0

1 = All figures in percentages; n.a. = Not available.
Source: Wilson *et al*. (1990).

Q. Discuss the modes of camel transportation and the care required during this process.

Camels having gone through the basic training to lead and couch are not difficult to transport and are usually not prone to panic. For journeys requiring more than one hour, it should be possible for them to couch. Trucks of almost any description can be used to transport camels. In a standard pick-up truck, 2 adults or up to 4 yearlings, restrained with ropes in couched position, even without head restraint, can be easily transported. In the UAE, racing camels are commonly transported in purpose built tandem trailers behind 4 wheel drive vehicles. These trailers accommodate 4 to 6 couched and restrained animals, and have sides. 1.5 metres in height. The floor is covered with vinyl covered foam plastic about 15 cm thick. Journeys of up to 9 to 10 hours have been made in this way. It is, however, advisable to provide some relief and exercise during the trip to avoid severe damage to animals.

At the Scientific Center for the Racing Camels (Dubai), a covered truck was designed by Manefield and Tinson in early nineties to transport 8 to 10 standing camels. The truck was equipped with a hydraulic tailgate, which when surrounded by panels, acted as a loading/unloading platform, without the necessity of a ramp.

Transport by Air: It is quite common for camels to be transported by air for up to 4 hours journeys in Middle East and North Africa. They are scissor lifted in a transfer box, walked into the aircraft, couched and restrained with ropes on bedding of hay. Camels going from Australia to the Middle East are transported in padded boxes. They are fitted with a strong neck strap. A rope from this is taken through a hole in the front of the box and tied to a strong metal fitting. This arrangement allows the camel to stand or couch, but prevents them from rearing to hit the ceiling of the aircraft with their head. Hay bedding 15 to 20 cm thick is used. Thirty-four wild camels, after 3 months training, were air transported from Australia to the UAE in 2.5 sq. metre crates with 1.6 metres height. Dividers were used to accommodate 2 or 3 camels per crate, depending upon the size of the animals. Since these animals had received only basic handling after capture, therefore

a sedative (Rakelin, 4 ml IM) was administered 3 hours prior to loading. The International Air Transport Association, however, stipulates that camels should be individually boxed during air transportation. Recently captured camels mostly do not like segregation. Five hundred untrained, untranquillised camels were successfully transported from Australia to USA. The largest single consignment was 114 camels. The body of the aircraft was divided into pens 1.2 metres in height. The camels of 300 to 350 kg body weight were driven into the aircraft using a loading ramp and confined 8 to 10 per pen. This provided sufficient room for camels to couch.

Ramps: sometimes portable ramps are used and these make a hollow sound under feet that alarms the camels. This can be minimized by a layer of sand 10 to 15 cm deep. The sides of such ramps should be at least 1.8 m high. Any cross bars, such as may be used to prevent spread of the sides, should be a minimum 2.5 metres high above the floor. The width of the ramp and lead up races should not exceed 85 cm to minimize the chance of animals turning around.

Sides and Floor of Vehicle: The sides of the vehicle should preferably be 2 metres high and any overhead spread preventers or roof on the truck should be no less than 2.5 metres above the floor. Camels should have a minimum of 15 cm clearance above their heads. The best trucks are designed with a roof and railed right up, or steel meshed above the rails. This prevents the camels from protruding their heads sideways and being struck by another passing vehicle. In vehicles in which heads can be protruded, camels may be tied down. The floor of the vehicle should be covered with about 10 cm of sand or dirt. This may be wet to prevent it blowing out. The floor of the vehicle should never be covered with gravel to avoid serious foot and kneeling pad damage (Manefield and Tinson, 1997).

Number of Camels: The number of camels that can be carried in a vehicle is determined by their size and age and the distance to be traveled (Table 22). If it is a longer distance, they should be given room to couch as they wish. Over shorter distances more can be carried and the animals forced to stand. Before loading, the camels should be sorted for size and kept separate in the truck to avoid smaller animals from being injured. Every 3 metres or so along the truck, a dividing, cross panel should be fitted. This provides a check for the animals to crowd to one end otherwise injuries and even deaths may occur. Properly loaded adult camels may be traveled for up to 2 days without release, provided they have been watered before loading. Juveniles should be allowed to nurse their mothers once or twice daily, depending on age. If sufficient room available they may be penned with their mothers. The following table indicates the maximum camel stocking densities in motor trucks with a deck width of 2.44 metres.

Table 22. Maximum camel stocking densities in motor trucks (deck width 2.44 metres)

Camel size	Truck deck length	
	5 metres	**12.2 metres**
Yearlings	12	26
250-300 kg	10	22
350-400 kg	9	20
500 + kg	8	16-18

Source: Manefield and Tinson (1997).

What has been said about the transport of camels by road, almost the same applied to their transport by rail. More attention should be given to the possibility of camels protruding their heads from the rail trucks.

Sea Transport: Camels have difficulty walking down steep ramps and negotiating tight turns, which may be necessary to reach some position in a ship. Camels are generally restricted to decks, which provide them with sufficient head room and access. Ships can carry much larger number of camels compared to other modes of their transport.

Q. What purpose is served by determining age of camels. Give detailed formulae for deciduous and permanent teeth in the camel. Also give the method to examine the teeth.

Most camel herders will know the age of every single animal in their herds yet proper determination of age can be important when it is traded, when treated for an ailment or when a decision on breeding has to be made. When records of birth date are lacking, examination of teeth is still a reliable method for estimating age. Estimation of age is based on information regarding time of eruption, shape and angle of teeth and signs of wear.

Examining the Teeth: To examine the teeth the camel's head is restrained by grasping the upper and lower lip. If need be a mouth gag may be applied. The head is then slightly pulled downward. During examination, camels usually vocalize a lot. Due to small and narrow space of the camel's oral cavity, the premolar and molar teeth are difficult to see or examine. Age determination therefore is mainly based on the appearance, shape and angle of the frontal teeth including incisors and canines.

Dental Formulae: The dental formulae of the camel differ from those of true ruminants by the presence of incisors (I) in the upper jaw and of the canines (C) or tushes as they are sometimes known, in both upper and lower jaws. The formulae for the dentition of camels, including premolars (P) and molars (M) in both the deciduous and permanent teeth are:

Deciduous : (1 1/3 C 1/1 P 3/2) 2 = 22
Permanent : (1 1/3 C 1/1 P 3/2 M 3/3)2 = 34

Estimation of the age of camels using dentition is possible, but requires some experience and skill. This is mainly because of the difficulty in distinguishing clearly between the deciduous and permanent incisors as there is not much difference in the sizes as it does exist in true ruminants.

Q. What factors may affect the appearance and shape of camel teeth?. In animals older than 12 years, what factors other than teeth can be relied upon in estimating age of camels?

Appearance and shape of teeth can be greatly modified by the quality of diet, nutritional deficiency, congenital malformation and dental diseases. Furthermore accumulation of tartar, discolouration and accidental loss of teeth can lead to wrong age estimation. The 'tushes', upper and lower canine, upper incisor 3 and upper and lower premolar 1 are

very well developed in mature males. In females and geldings these teeth are less developed or even absent. For aging camels older than 12 years, one has to rely heavily on experience in judging wear of teeth, available history of the animal and good judgement of physical appearance. In addition, other guidelines such as appearance of the animal, sexual maturity, known calvings in females, signs of advanced age such as grey hairs, scars and skin texture can reasonably help in estimating an animal's age (Tables 23 and 24).

Q. Give details of camel dentition in tabulated form, including number and types of temporary teeth along with their time of eruption.

Table 23. Temporary teeth of camel

Type of teeth and jaw	**Eruption**	**Comment**
Upper jaw		
Incisor 1		Absent
Incisor 2	Never	rudimentary, completely covered by gums
Incisor 3	2 to 4 months	Very small (just pea size); not always present
Canine	2 to 4 months	small blunt, slightly pointed forward; 1.5 cm long
Premolar 1	1 month	sharp cutting edges; distinct neck
Premolar 2	1 month	triangular occlusal folded surface; distinct neck
Premolar 3	1 month	square shaped; folded occlusal surface; neck less distinct
Lower jaw		
Incisor 1 (center)	14 days	small, conical with a well developed neck; forms an angle of 45 degrees with the mandible
Incisor 2 (lateral)	14 days	
Incisor 3 (corner)	1-3 moths	
Canine	2-4 months	having shape like incisors
Premolar 1	1 month	rectangular; distinct neck
Premolar 2	1 month	rectangular; no distinct neck

Source: Schwartz and Dioli (1992).

Table 24. Permanent teeth of camel

Type of teeth and jaw	**Eruption**	**Comment**
Upper jaw		
Incisor 1	-	Absent

Incisor 2	-	Absent
Incisor 3	5.5 to 7 years	third pair of ‘tushes’; thick pointed, slightly curled backward; no distinct neck
Canine	6 to 7 years	knife-like sharp borders; much smaller in females; 5 cm long in males
Premolar 1	6.5 to 7.5 years	may be absent in females; short and thick; slightly curved backward
Premolar 2	5 to 5.5 years	small; triangular; distinct neck
Premolar 3	5 to 5.5 years	circular; twice in size of premolar 2
Molar 1	12 to 15 months	square shaped with distinct neck
Molar 2	2.5 to 3 years	rectangular; no distinct neck
Molar 3	5 to 5.5 years	pyramidal; no distinct neck
Lower jaw		
Incisor1* (center)	4.5 to 5 years	spatulate; no distinct neck; at 45 degrees with mandible
Incisor2* (lateral)	5.5 to 6 years	spatulate; no distinct neck; smaller than incisor 1
Incisor3* (corner)	6.5 to 7 years	spatulate; no distinct neck; smaller than incisor 2
Canine	6 to 7 years	the same as in upper jaw
Premolar1	6.5 to 7.5 years	second pair of ‘tushes’; short and thick; may be absent in females
Premolar2	5 to 5.5 years	triangular; distinct neck
Molar 1	12-15 months	rectangular; distinct neck
Molar 2	2.5 to 3 years	rectangular; no distinct neck; twice in size of molar 1
Molar 3	5 to 5.5 years	rectangular; no distinct neck; largest teeth in mouth

* In camels the angle of the incisors changes from approximately 30 degrees in young animals to nearly perpendicular in old animals.

Source: Schwartz and Dioli (1992).

Table 25. Age determination in 1 to 7 years old camels

Teeth	**11**	**12**	**13**	**C**	**P1**	**P2**	**P3**	**M1**	**M2**	**M3**
Age and jaw										
1 and 2 years										
Upper	-	-	D	D	D	D	D	P	-	-
Lower	D	D	D	D	D	D	-	P	-	-
13 teeth										
3 and 4 years										
Upper	-	-	D	D	D	D	D	P	P	-
Lower	D	D	D	D	D	D	-	P	P	-
15 teeth										
5 years										
Upper	-	-	P	D	D	P	P	P	P	P
Lower	P	P	D	D	D	P	-	P	P	P
17 teeth										
6 and 7 years										
Upper	-	-	P	P	P	P	P	P	P	P
Lower	P	P	P	P	P	P	-	P	P	P
17 teeth, all permanent; 34 in all, including right and left of both the upper and lower jaws.										

I = Incisor; C = canine; P = premolar; M = molar; D = deciduous; P = permanent.
Source: Schwartz and Dioli (1992).

Q. Name certain vices commonly observed in camels and suggest measures to control them.

Biting: A simple measure to control a biting camel is to keep it muzzled at all times except when eating and drinking.

Bad Kickers: Such camels may be controlled by the use of spider hobbles that attach to all four legs, or tie the halter fairly close to a solid rail, then walk behind the camel just out of kicking range and allow it to kick into nothing.

Cud Spitting: During training or otherwise, cud spitting is certainly unpleasant. Cud spitting is not performed in the sense of a bolus being aimed at an object or a person. It is the result of a vocal complaint producing exhalation forceful enough to eject and scatter ruminal contents that happen to be in the mouth. To avoid this unpleasant happening, just be careful that before attempting to carry out any close procedure, pause and allow cud to be reswallowed, then move in quickly and accomplish the task.

Refusal to Respond: Repeated punishment (hitting) and heavy use of whip only reinforced refusal. Camels, however, respond well to sensible and conservative use of an electric goad. The animal should be introduced to the obstacle and taken as close as possible and the goad used quickly, just as it is about to refuse. However, if the animal starts to frenzy, all attempts to move it should cease and it should be allowed to rest 15 minutes before retrying. Properly used electric goads have proved invaluable aids during

exercise and training of camels. Once they are used to them, the device often has only to be lifted and displayed behind a slacking camel for effort to be renewed. Electric goads have become items of essential equipment in camel transport and saved much time and effort of both men and animals (Manefield and Tinson, 1997).

Calf Care

Q. Give a brief account of the life of the camel calf during the first few months.

The camel calf is expected to stand and suckle within about 2 hours of normal delivery and to walk within next 3 hours. Some calves may initially require assistance to gain feet and may take up to 8 hours to stand and walk in a stable manner. Such weak calves should be carefully tended otherwise they may further deteriorate and die. Normally they are expected to follow their mothers within 48 hours of delivery. However, till the age of 1 year the calves are considered delicate and more prone to various ailments. A normal camel calf weighs about 30 kg (25 to 45 kg range) at birth and measures nearly 75 cm from the toe to the shoulder. Within the first week the calves investigate and may also nibble plants. By the end of 2 weeks they will be eating small amounts of herbage, whereas by 2 months of age they are found actively foraging. Male calves usually show faster growth than females but a reverse trend has been shown by some studies. Healthy calves exhibit three types of alternating behaviour i.e. suckling, skittish running/jumping and sleeping.

During their neonatal life camel calves need intensive care, otherwise as it does happen under traditional management, losses up to 35% are quite common. Much of this loss is associated with primary or secondary diarrhoea. By following a few simple principles such as trained attendants, adequate health cover and continued supervision, can reduce the losses to less than 10%.

Q. What do you know about camel neonates? Describe briefly.

The birth weight of camel neonates varies from 25 to 45 kg. Signs of premature births are obvious weakness, lower body weight, general lack of pigmentation and short hair with a silky feel. Within an hour or two a healthy newborn camel, although unstable, starts to get up and explores the mother to find the udder. The young camel is a ‘follower’ rather than a ‘hider’. The bond between mother and young appears strong although the mother does not lick the young. Calf rejection is common in young and inexperienced dams. Several traditional methods exist to persuade the mother to accept another young when she has lost her own. Various camel-owning groups use ‘dolls’ to encourage female camels to accept other calves. A ‘doll’ is made by skinning the dead calf and placing the skin on another calf to be presented to the mother who lost her calf to fool her into thinking that her calf is alive.

Because of the long interval between calving and the extended lactation period, the bond between mother and young persists over a considerably longer period of time than in other farm animals. Immediate care of the neonate should include routine dipping with pyodine of the umbilical cord shortly after birth and the provision that adequate colostrum intake immediately or not later than 16 hours after birth occurs. Neonates who appear weak and show a poor sucking response should be bottle fed or incubated if feasible until they gain strength. Meconium is passed over a couple of days and retention

is rare. The most common neonatal diseases are joint ill and neonatal diarrhoea. The incidence of congenital diseases such as angular limb deformity is generally low.

Q. What factors specifically contribute to the increasing camel calf mortality?

Camel calves are delicate creatures and are relatively more prone to various ailments until they pass 1 year of age. In many parts of Africa and some adjoining areas of Asia, 30% mortality is an accepted norm which may go up to 50% in unfavourable years. Low birth weight and premature calf births most often meet a fatal end. Infanticidal activity of some bulls in rut is also a factor but a minor one. Inclement weather particularly severe winter with cold wind and rain is very dangerous to calves less than two weeks old.

In some pastoralist camel cultures the practice to deprive calves of colostrum leads in turn to depriving them of valuable passive immunity, thus exposing them to several diseases. Pregnant camels may be timely vaccinated against diseases such as anthrax, camel pox, rabies and clostridial diseases. This should help in minimizing the diseases. The diet of pregnant camels should be adequately supplied with essential minerals and vitamins to ensure production of healthy calves.

Diarrhoea, probably due to excessive intake of milk, is the main cause of deaths in calves. *Escherichia coli* and/or corona and rotavirus are the primary or secondary sources of infections. Protozoon parasites causing coccidiosis and giardiasis also play their part. Vitamin E/selenium deficiency causes severe losses from the age 6 weeks to more than one year. Such deaths may be prevented after administration of Selvite-E 3 ml IV, Dexone-5, 5 ml IV and daily doses of Selevite-E 25 g PO. The deficiency can be avoided if the diet of both mothers and calves contains 0.1 to 0.5 mg/kg body weight of selenium and the intake of vitamin E (tocopherol) is >100 mg daily. Camel pox can cause deaths in 25% of the affected calves from the age of 3 to 4 months. Specific, attenuated and inactivated vaccines are available. Heavy tick burdens and heavy nematode infestation, particularly with Haemonchus, are associated with death in young calves. Outbreaks of enterotoxaemia (*Clostridium perfringens* type A) can cause deaths in calves. Predation by various carnivore wild animals can also be a problem. Apart from these factors, periparturient husbandry is important. When space permits, camel cows naturally choose isolation at the time of parturition to avoid interference from other animals, particularly rutting males who have been reported to cause actual physical damage to the neonate. Areas of confinement (paddocks) should be large enough to allow this to happen in more than one animal depending upon the size of the herd. There is an additional advantage in providing such isolated areas in that they do not get heavily contaminated and there is much less chance of infection via the navel. Ideally, these paddocks should be used only during the calving season and kept free of camels otherwise. These areas should have some natural shelter such as bushy shrubs or sand dunes to protect the neonate from chill. The cow should be observed as unobtrusively as possible and only interfered when dystocia is suspected. Allow the mother and the calf to avail isolation for up to 2 weeks. Regular observation, of course, should continue during this period coupled with proper feeding of the mother. After the first 2 weeks, both of them may be moved into a larger group with mixed age calves. The calf may be temporarily identified with its mother. A schedule of vaccination and parasite protection should be established according to

knowledge of disease occurrence in that region. Diseases that can be prevented by vaccination include anthrax, rabies, tetanus, camel pox, enterotoxaemia and other clostridial diseases (Manefield and Tinson, 1997).

Q. Suggest a few practicable techniques to foster a camel calf to another milking female whose calf has died.

Due to maternal death, poor milk supply or for other reasons, it becomes necessary to foster a calf to another milking female. Various techniques are used to induce the foster mother to allow the calf being fostered to suckle. These techniques are: placing the skin of the foster mother's own dead calf onto the calf being fostered; alternatively smearing the foster mother's nose with an ointment so that she cannot smell properly the new calf. In case these techniques have not met success, another method rather traditional in character, has more chance of being successful. First block the foster mother's nostrils with cloth plugs. Then take a double handful of the foster mother's own faecal pellets and wrap them in a cloth to form a ball. Next, carefully insert this ball into the rectum and to retain it there, place a single mattress suture to block the anus. She is then walked about 2 km and returned to where the calf is waiting in a yard. The calf is then allowed to drink from her for a short period while she is properly restrained. Both of them are then left together in a confined space until the foster mother appears to be comfortable with the calf's presence. The suture is then removed along with the ball from the rectum followed by the cloth plugs from the nostrils. The calf and the mother are kept confined for the next a few days.

Q. Write a note on weaning of camel calves.

By weaning camel calves at too young age and/or too suddenly, they suffer marked growth retardation. The usual practice followed by camel raising tribes is weaning the calves at the age from 12 to 18 months, since it is in line with their requirements for milk for domestic use. When milk is required for domestic purposes, delayed weaning has the advantage of prolonged lactation through the stimulus provided by the calf. For experimental purposes, calves have been weaned as early as 1 month at UAE University but these require special attention, and even weaning at 3 to 4 months is almost impracticable under field condition. The suggestion by some quarters in respect of weaning at 6 months sounds as easier said than done. It presently seems possible only at research station and specialised camel farm situations. Weaning at 9 months would still give time for another calf to be born within the acceptable norm of 24 months.

Without the daily injection of hormones such as growth hormone and oxytocin, lactation ceases in the absence of the calf. Udder bags are attached to the camel to prevent the calf sucking. After milk is taken for domestic consumption, the calf is allowed free access to the udder for a period and the udder bag reapplied. This arrangement allows the mother and the calf to be together, whether foraging or restricted. Shock of weaning can be reduced by the practice of creep feeding. Calves will eat adequate quantities of forage and prepared feeds from the age of about 8 weeks. Milk based pellets such as Nutricamel (a milk based feed supplement containing 45.8% protein, 7.8% fat, 2.9% fibre, 10% lactose and vitamins and minerals), mixed with other grain can assist in avoiding this problem (Manefield and Tinson, 1997).

Q. Write a note on calf feeding.

As with other neonates, the camel calf's very first drink should be colostrum from its mother, which is produced during the first about 5 days of the lactation. In case of death of the mother, colostrum from another camel may be fed to such a calf. Generally, the calf is allowed to suck twice a day, but if the quantity of colostrum or milk secreted by a dam is small or inadequate, the calf is allowed access to the udder three or four times. The practice with some cultures in denying the calves colostrum contributes to calf mortality. The calf of a good milker should be allowed milk from only one teat since excessive intake of milk often results in diarrhoea. After 10 days or so the quantity of milk used by calf may be increased gradually. At this age the calves also start nibbling at plants and by 2 weeks they will be eating small amounts of herbage. By 2 months of age they are actively foraging as the rumen is developing. Allowing them out with their mothers encourages the calves to forage earlier. This practice assumes more importance in those regions where the calf is in competition with humans for milk. Satisfactory calf growth occurs when the calf is allowed to suckle by day and the night the milk saved from the humans, provided that the calf is not weaned for several months, at least up to 9 months. A later weaning age will compensate for milk restriction earlier, but it is early milk that maximizes growth rate. The young camel calf is more dependent upon milk than buffalo or cattle calves of similar age. There is evidence, however, that restricted milk intake at later stages induces the calf to forage earlier and reduces the shock of weaning.

Creep feeding is a satisfactory means of early introduction of calves to alternative nourishment in breeding farm situations. Calves start showing interest in mother's trough at about 2 to 3 weeks age. Providing a creep with a coarse meal for the calves would seem to be ideal. The creep feed should contain about 12% of good quality protein.

Camel Training

Q. Write down the procedure for basic training of the camel.

Basic training of the camel is initiated at the age of 1.5 to 2 years. The first step in this direction is to condition the animal to accept close human presence and handling. An attempt is made to bring the animal to a confined space so that a halter can be fitted to its head. It is then secured to a small fenced area or better secured to a fixed object with a travelling ring attached to the halter rope to allow the camel to circle the object without entanglement (Figure 27). The trainer then proceeds to work in the vicinity of the camel while gradually working towards it and finally being able to pat it. The camel may be left tied for several days until it has accepted the halter and patting from the trainer. The acts of watering, feeding and talking to the animal in encouraging tones assist with the acceptance process. Depending upon the tractability of the individual animal, acceptance of hobbles on the front legs should often be one of the early lessons. However, during all this exercise, it is well to remember that the camel can kick very accurately in any direction. Its hind legs too can reach the point of its shoulder. It can strike very effectively with the forelimbs and can kick backwards at any object in reach.

If the handling process needs to be hurried, one of the camel's front legs can carefully be manhandled and tied in complete flexion, the trainer thus feels safer. It is, however, wise

to allow plenty of time to win the confidence of the animal than to make hurry. No doubt, some animals respond more quickly than others do. When the camel yields to the use of halter on its head, leading it becomes relatively easy. Aids such as leading along side trained camels or a helper walking along with a handful of fodder can tempt the animal to move ahead to get the fodder. Once the animal has learnt leading reasonably well, it can be taught to couch or assume sternal recumbency on command. The command words should not be changed once the camel has begun to obey the command to assume a couched position. Couching is natural to the camel, what needs to be taught is that it should also become couched when asked during work. Downward pressure is applied to the halter rope and the command word clearly and repeatedly given. If the desired response is not forthcoming, the ground in front of fore feet is beaten with a switch. If still no response, the feet and metacarpus are tapped with the switch and continuous downward halter pulls along with repeated use of basic command will work.

Patting/touching, rubbing, grooming etc. should commence on the body then proceed to the neck and finally the head. Even quiet, well-handled camels may never lose the habit of complaining vocally when they are handled, particularly close to head. When the camel is leading and couching well, a saddle can be introduced. An old saddle with a plenty of camel odour is usually preferred. The saddle should be fitted comfortably and firmly with the animal in couched position, and then the camel led about until the saddle is calmly accepted. Weight in the form of sandbags etc. can then be progressively added but kept light in immature animals. The camel is now trained to be a pack animal and even if destined to be a riding camel, it may benefit from light pack work training until it is mature enough to bear a rider. Large pieces of cloth and things of that sort may be left to dangle from the rigging to accustom the animal to strange objects and happenings, which might otherwise 'spook' it later when being ridden.

Riding Training: Mounting and dismounting the camel in couched position are the first steps in riding training. When this much accepted, the camel can then be stood up under rider with the head being held by another person. Camels can buck but not as effectively as horses. For the first few rides the young camel is best led from a trained camel. Reins may be fitted from the first ride but no attempt is made to use them until the camel is well settled and accepts the rider. Once it is assured, the training rider will commence to gradually take more control of the camel and the leading rider gradually transfers more to him. Reins, one or two, may be attached to the halter or even tied around lower jaw behind the canine teeth. Nose lines attached to a nose peg, are necessary to restrain for forward movement of many camels. Camels often do not rein control as effectively as horses, probably because of their peculiar morphology. They can be trained to some degree of response to the rider's legs and feet, aided by threats and taps of the rider's cane. The discipline and response of the camel, just as with the horse, will ultimately depend upon the skill, tact and patience of not only the initial trainer, but more so of those who use it after initial training.

Camel Training in Indo-Pakistan Subcontinent: In India and Pakistan, camels are still employed for patrol work by the Border Security Force (BSF) and the Rangers. Basic training of camels is almost the same as already described. The highly skilled trainers and

riders of the BSF/the Rangers have trained their animals to perform entertaining musical rides. Many of these rides are performed using a lofty gait similar to some of the movements seen in equine passage and collective trot. The optimum age for such training is 3 to 5 years. It takes 2 months to teach a camel a basic range of evolutions. Once the ability to learn is established, each additional capability may be acquired in about 2 weeks. All training is done with extended rope halters. The use of whips and sticks is avoided. The BSF performs at many festivals in Rajasthan. The Rangers display the feats of their camels at the grand annual National Horse and Cattle Show in Lahore, often with more than 50 trained camels. Their evolutions both in India and Pakistan include passage, crawling on the knees, backing, single and multiple gymnastic riding, camels carrying lighted fire sticks through fiery hoops and all sorts of parades in troops.

Q. What different commands need to be taught to the camel as a part of the basic training?

Basic training is a must for all camels. It includes the commands to sit, stand up, lie down, forward and backward movement, varying pace of gait and halt. These commands are essential in order to carry out a routine draft or pack work. Many times young camels, if kept together with adults, learn these commands when being taught to the latter. This not only provides a base from which the camel can be put to special training but also inspires discipline in the camel to obey the commands of his master/rider. Generally, these commands are picked up by camels in about 6 to 8 weeks.

Q. Having received the basic training, what events are usually performed by the camel after being specially trained. Write notes on any three of such events.

The list of events includes: camel parade, camel band, physical training (P.T.), saluting, crawling, formation of figure of eight, acrobatics, pulling camel carts, dancing, camel polo, camel racing, camel wrestling and military training (Gahlot and Chadha, 2000).

Camel Physical Training: This is mostly performed by a group of 24 camels arranged in four rows with six camels in each. In first row all camels remain in lateral recumbency. In second row all camels remain sitting. In third row all camels are in a front leg kneeling posture while hind quarters remain in a standing position. In fourth row all camels assume standing posture. Camels participating in this event are trained on a ground having straight white lines. Camels in each row are not interchanged and they are trained first separately in each row to achieve perfection.

Saluting: It is performed during sitting or standing position. A group of five to six untrained camels with one trained camel in the center are given practice with a simultaneous verbal recitation of command 'salute'. Every time when the command is repeated, the nose rope is pulled down and simultaneously the rider strikes a wooden stick at the poll region of the camel in order to lower down its head and neck. About six weeks training makes the camel to salute on a verbal command and a simple movement of the stick.

Camel parade: It is an essential training for every camel in the Rangers Camel Corps. Usually camels aged between 5 to 6 years are introduced into the Corps. The camels are made highly disciplined like soldiers. The nose pegs are fitted. The training is generally imparted by experts of camel training called instructors/inspectors. Various verbal

commands are given to the camel many times a day. In the morning and evening hours, camels undergo routine exercise. Camel parade is taught on the beat of drum where a trained camel is flanked by 6 to 7 camels on either side with a rider on the back of each one of them who ensures synchronization of steps of camel with the beat of drum or to follow step by step by looking to the right and left. This practice is continued for 3 to 4 months to achieve perfect coordination.

Acrobatics: In acrobatic event, the rider performs more than the camel, however, demonstration of the rider on one or two camels requires simultaneous training of camels too. In the event of one rider standing and balancing on two camels, both the camels are given practice to move parallel and straight by tying a rope around their necks. Both camels are forced to run on a short track for 5 to 7 days. Once synchronization is achieved in their gait, then both camels are ridden by one rider only, while putting his one leg on each camel. The rider gives signals to the camel(s) by pressing his heel against the back of the camel. Other acrobatics include performance of the rider on a moving camel e.g. adopting sleeping posture on the running camel, hanging of rider on either side of saddle and turning upside down on the back of a camel. Different acrobatic events are practised many many times so that the rider and the camel act like two parts of the same body and have perfect understanding (Figure 28). For more details on camel sports and racing, the reader is referred to Gahlot and Chadha (2000).

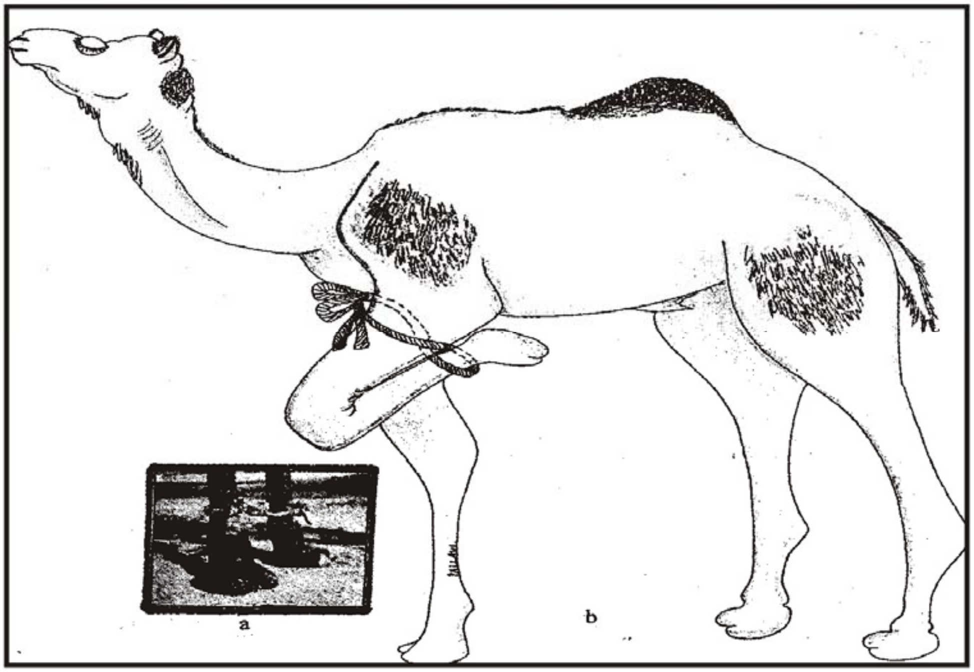

Fig. 24a. Restraining of forelimb in a standing camel with a rope. a) both the forelimbs, b) one forelimb

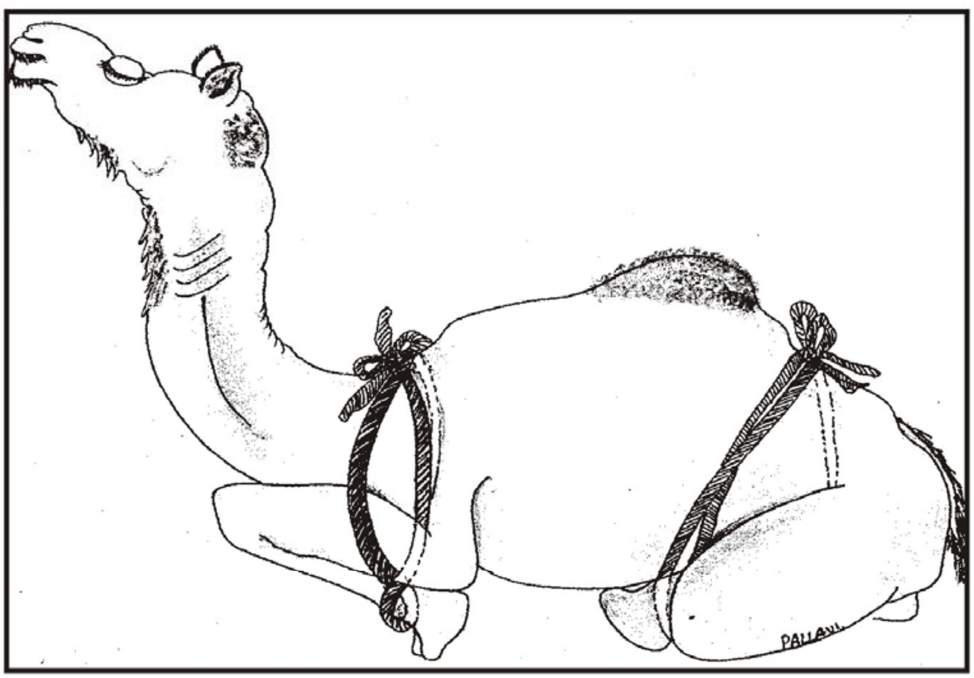

Fig. 24b. Restraining a sitting camel with ropes around forelimbs and neck and hindlimbs
Source: Gahlot (2000).

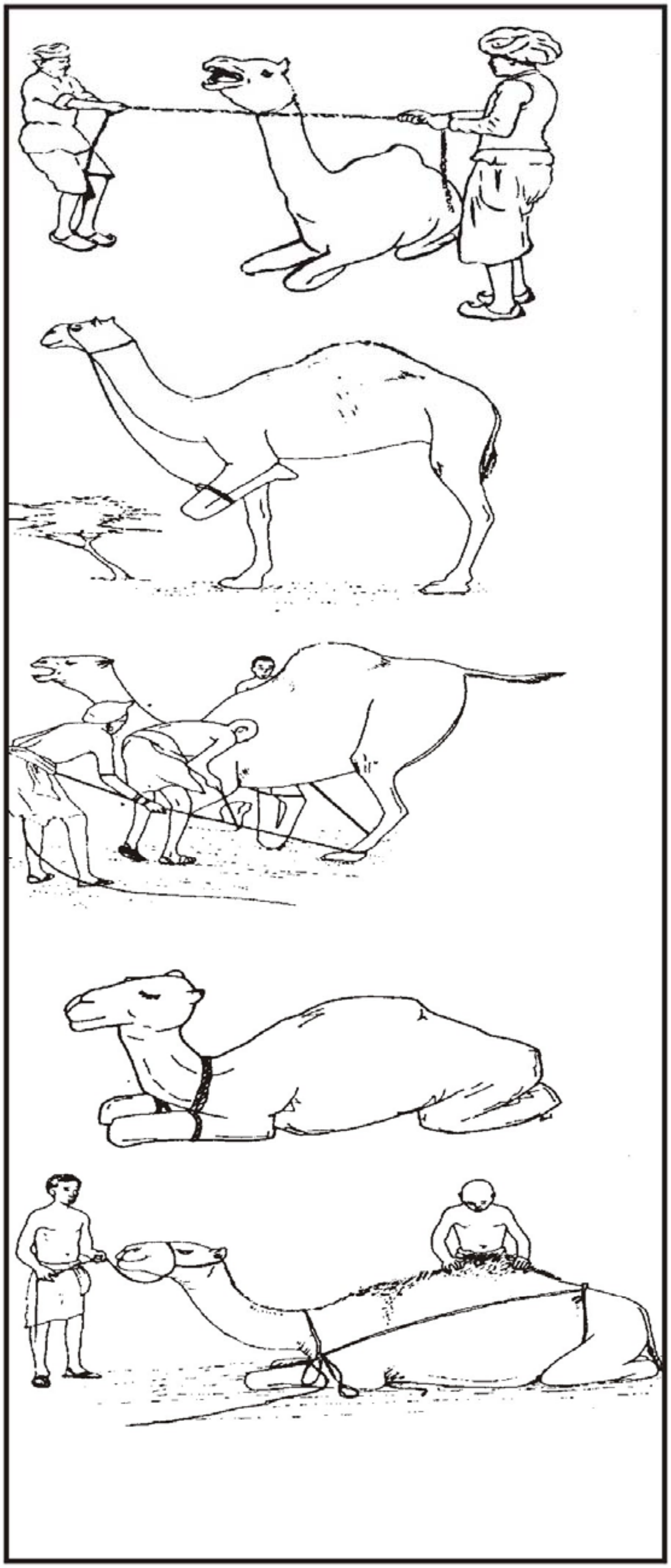

Fig. 25. Various other methods of restraining camels
Source: K. Rollefson *et al*. (2001).

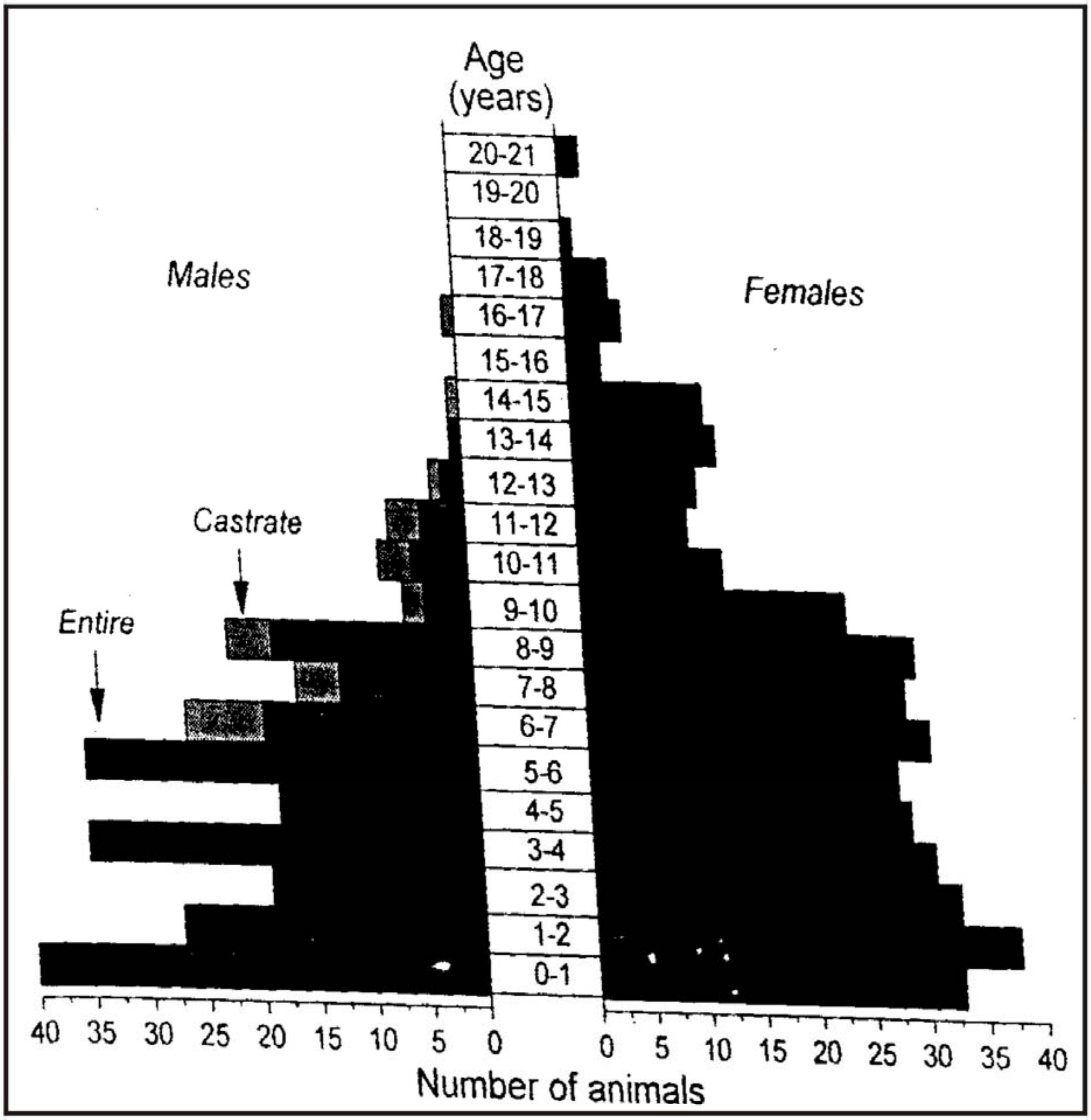

Fig .26. Pyramid showing herd composition by age and sex
Source: Wilson and Wagenaar (1982).

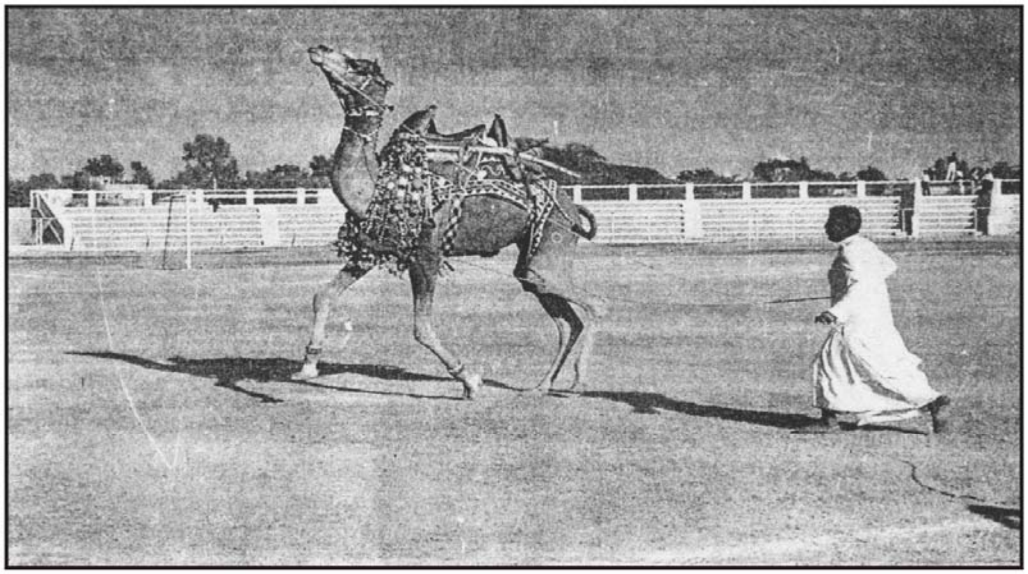

Fig. 27. A camel in fast gait being controlled by a rope halter
Source: Gahlot and Chadha (2000).

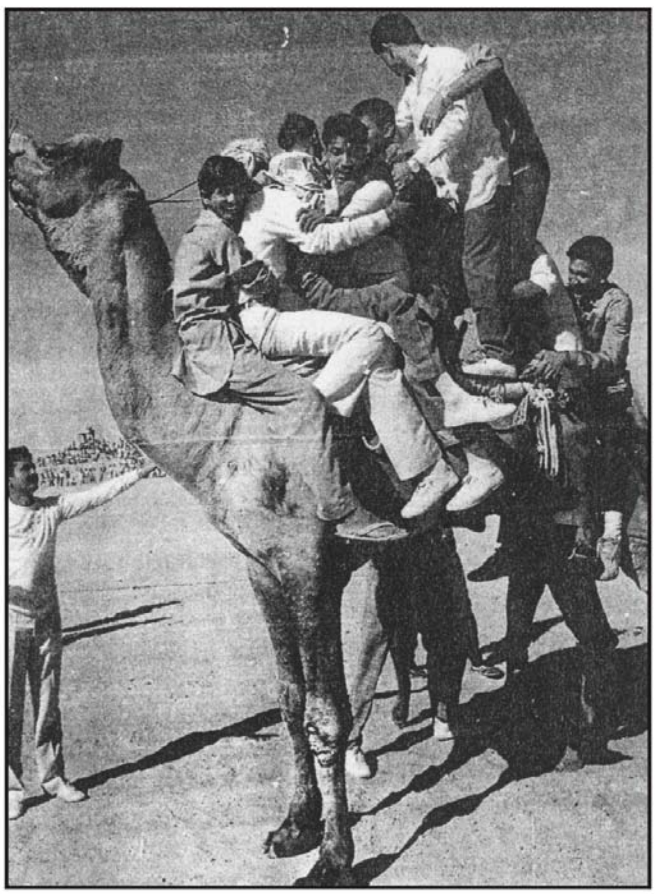

Fig. 28. Several riders on a camel's dorsal line from neck to tail
Source: Gahlot and Chadha (2000).

LOCOMOTION AND GAITS

Q. Write a note on the position of center of gravity in the body of the camel.

In a standing still camel with its limbs evenly weighted, the center of gravity is where the median plane intersects transverse plane. If the trunk is taken as the linear distance between the cranial surface of the shoulder joint and the caudal surface of ischiatic tuber, then the transverse plane lies about 42.11% of the trunk length (42.86% in horses and 43.72% in dogs) i.e. about 64 cm behind the point of elbow about the level of 8^{th} intercostal space. Thus, the center of gravity lies nearer the front edge of the body than the back one (Figure 29). However, the position of center of gravity is not constant. It shifts backwards in case the head is lifted, abdominal organs are distended or the tail is extended. On the other hand, it shifts forwards when the head and neck are lowered, or if the abdominal organs are empty. The position of the center of gravity is of great importance in the saddling of the camel and the seating of the rider. It also determines the proper distribution of the load placed on the back of the camel. Another important point is that the body weight is not evenly distributed through the four limbs. Since the center of gravity lies nearer the forelimbs, they carry more weight than the hind limbs even if the animal is standing square (Saber, 2000).

Q. What movements can take place in the camel without change in location?

These movements are: couching, lying down, rolling, rising and kicking. Couching (sitting down): Sitting down is done more or less slowly and jerkily. At first the camel slows on one knee (carpals) rested on the ground, followed almost simultaneously by the other knee. Then the hind legs are bent until the pads touch the ground. The forelimbs are then settled down so that the bent forelegs extend symmetrically forward from the trunk. Finally the bulk of the weight is taken on the breast pad (sternal callosity). A camel can spend a long time in this position, exposing minimal body surface to the sun rays, supporting its chest weight on its sternal callosity, ruminating, resting, sleeping, or even feeding if there is any feed within its reach. If the camel is tired, it may stretch its neck forward along the ground. Llamas also assume the same position in line with their body and fall asleep in that position.

Rising: All animals, especially carnivores, can rise suddenly when startled. They almost immediately roll onto all four legs and rise. When rising the camel thrusts its head forward with a jerk, then rises to its knee so that the radius and ulna are vertical. Then it lifts the hind quarters to the full extent, and one foreleg is then lifted until that foot is flat on the ground. This leg is then used to lever up the whole animal body until the animal is erect. The opposite foreleg is last to touch the ground. Camels have difficulty in rising if one of their legs is injured, they may lie in one place for as long as a week until the leg is strong.

Rolling: It is a natural way of grooming and skin massage. Together with rubbing and scratching, rolling on ground constitute common comfort movements of camels. The camel rolls from side to side, flexing and extending its limbs with sudden jerking movements while throwing the head over the back and withers. Camels, horses as well as

true ruminants are required to put much effort into rolling because of their comparatively rigid trunks.

Kicking: It is defensive movement. It can be performed with either one or both fore- or hindlimbs. In llamas, a high-ranking female in the wild or in captivity may attack a young male by kicking him with both front legs alternately and then chasing him away. The act of kicking is achieved through a short flexing movement, quickly followed by a sudden aimed extension, afterwards the leg is placed on the ground again.

Miscellaneous Movements: There are certain other movements performed by either the fore- or hindlimbs or by both for some special acts such as scratching and rubbing or even fighting and biting. Public camel fights are still organized in some countries such as Tunisia, Turkey, Afghanistan, Pakistan and India. The most frequent type of scratching is with a hindleg against a foreleg, the brisket, the neck or the head. Camels can scratch their flanks and can even reach their withers and tails with their long necks.

Camels dislodge flies and other insects in a number of ways by raising the head quickly, shaking the raised head and the flaccid lips, flickering ears, throwing the head down and back against the side of the body, while simultaneously blowing out, bending a front leg quickly so that the foot touches the chest, rubbing the legs against each other, jerking the hind foot forward so that it touches the front leg, and by swishing the tail, either slowly and horizontally or quickly and vertically (Saber, 2000).

Swimming: Various reports indicate that camels can swim well without trouble.

Q. What type of camel movements are called locomotions?

The movements that take place with change in location are called locomotions. Principally, they consist of shifting the center of gravity forwards, to the side or backwards. The natural form of locomotion in all domestic mammals is forwards. Lateral and backward movements are only performed as a necessity when playing, fighting, attempting to outmaneuver some obstruction or for exhibition and competition purposes. The angulations of the limbs and the arrangement of the musculature of the extremities also appear to be favourable for forward motion. The center of gravity can swing to left or right of the midline, accompanied by a rhythmic sideways motion of the trunk, head and tail. These rhythmic movements of the head and tail contribute much to the maintenance of equilibrium during locomotion.

Both the thoracic and pelvic limbs exhibit the following four phases of movements, which can vary in duration by remaining constant in sequence:

i) The first phase ‘lifting phase’ is the moment the limb starts getting lifted.
ii) The second phase ‘swing phase’ is raising the limb off the ground.
iii) The third phase ‘supporting phase’ being once the foot is placed on the ground again.
iv) The fourth phase ‘thrust phase’ in which the weight of the trunk initially tends to flex the joints of the supporting limb.

The sequence of movements occurring between one lift phase and the next is known as a step and the distance covered between the two is called a step-length. In locomotion all

four limbs work in harmony. The forelimbs only support the trunk during the thrust phase and also when the animal is climbing a steep slope, or when it is pulling a heavy load. The hindlimbs, however, propel the trunk forwards during the supporting limb stage.
The camel, like other domestic mammals, has varying classes of locomotion. These classes include the walk, pace and gallop.
Walk: The walk is the slowest form of forward locomotion. It is a long synchronized stride that involves the whole weight of the body being supported for a very considerable part of time on either the two right or the two left legs. This gait is normal at the walk and is long and slow, averaging 38 to 43 steps per minute in the adult animal and economy is achieved both in covering distance and in the energy used to attain this (Table 26).

Table 26. Data on speed, duration and length of strides at various gaits in camel

Gait	Speed		Duration of strides (seconds)	Strides per minute	Implied length of stride (metres)
	m/second	km/hour			
Walk	1.76	6.3	1.67	35.9	2.93
Pace	3.31	11.9	0.97	61.8	3.21
Gallop	5.20	18.7	0.56	107.1	2.91

Source: Dagg (1974).

The head, neck and tail follow the movements of the four limbs, the head and neck nodding rhythmically and the tail swinging from side to side. The head and neck are lowered at each swing phase of the forelimbs and lifted during each support phase. The trunk goes through horizontal and vertical undulations that can often be seen by the onlooker and noted by the rider.
Pace: It is a modified form of walk, producing a greater speed without any alteration in sequence of limb movements. It is a natural gait characterised by faster locomotion. The characteristic of the pace is its simple sagittal synchronism, which means that the camel’s legs of one side move together. Thus the movement of a camel in motion has been compared with that of two soldiers walking in step, one behind the other. A pacing camel can move at a steady speed for many hours. A pacing camel is usually supported by two lateral legs at a time, but at a slow pace it may also be supported for a short time by all four legs. At a fast pace it may not be supported by any leg for a fraction of a second at a time. It was reported that 83% of the time of each stride of a pacing camel was spent on unilateral legs, 1% on all four legs and 2% on two legs. The rest of the time was spent either on one or on three legs. The hind legs were on the ground more than the front legs, perhaps because slightly more propulsion is provided for the gait from hindquarters than from the forequarters. In the pace the body swings noticeably from one side to another as the weight of the animal is suppoted first by the legs on one side of the body and then by those on the other side.
The Gallop: The gallop is an asymmetrical fast gait in which the body is supported during a stride by any number of legs or by none at all. The gallop is hardly used by camels, except by the playful young and in some racing activities. In the galloping strides, which lasted 0.4 to 0.7 seconds each, the feet were placed on the ground in rotary

order rather than in the transverse order used by horses. The camel's footfall was thus right hind, left hind, left front, right front and so on. In the fastest galloping strides, front and hind feet were never on the ground simultaneously. The camel takes an excellent rider to stay on during galloping, because not only does the rider lack stirrups and reins but he must give his mount great leeway with the nose rope so that its head can move up and down with each stride (Saber, 2000).

Q. Does conformation has any bearing on movements of camels?

There is no doubt that the sound conformation of the body, in general, and the limbs, in particular, help the camel to move his body segments freely and to get the maximum use from these movements. The most prominent conforming characteristics of the dromedary are its well developed prominent thoracic limbs which are higher than the weak appearing pelvic limbs. Joint angulation is wider in the thoracic limbs compared to the pelvic ones. The forelimbs, therefore, appear straighter and more in line. Setting of the longer and wider front feet is square and even. The hind feet are slightly camped under and turned outward.

Q. Write a note on the camel feet.

Although the camel belongs to the order Artiodactyla, but its feet are not like those of other ungulates. Other ruminating members of this order have cloven hooves, whereas the camel's feet have large pads with two toenails. The front feet are larger than the hind feet, probably because of the long neck of the camel and because they support a great proportion of the animal's weight. The foot pad resembles a tyre, but it is filled with fat rather than air. The fat is arranged in a series of fatty pads which are mainly composed of neutral triglycerides, consisting of 75% unsaturated fatty acids (Figure 30). This type of fat becomes fairly liquid at low temperatures, thus enabling the camel to walk on cold surfaces without the pads becoming solidified. Other peculiarities, which are considered as modes of accommodation to the drastic changes in temperature during days and nights in the deserts are the elastic cushions and the yellow pad, in addition to the very thick epidermis (1.5 cm) of the sole. Moreover, the skin of the sole of the camel has very special vascular and nervous structures as well as glands, which are modes of thermoregulatory adaptation characteristic of the camel (Saber, 2000).

Q. Give below a brief account of camel gaits.

The walk, the pace and the gallop are considered as the natural gaits of the camel. Its slower gallop may be called a canter, which is a three-beat gait. Only at the start of races, very fast camels are able to enter into a 4 beat gallop for short distances. The ability to move in this fashion and maintain the gait is possessed only by exceptional camels. The walk is an easy swinging gait of 4 to 6 km/hour. At 6 km/hour the camel tends to be ambling. Rather than walk faster, the camel usually preferably adopts a swinging pace with the fore– and hind ipsilateral legs advanced in unison. With this gait it travels at 10 to 12 km/hour, maintaining this rate for many hours. At about 20 km/hour when forced to in the pacing gait, most camels are quite rough to ride. The speed a little faster than walk appears to be the camel's preferred gait. Among horsemen this way of going is termed as pacing and that term has been adopted here to indicate the particular coordination of leg movements. Among camel people it is very often jog. In horses only a minority naturally

pace, the vast majority have to be forced into this gait. It is a natural gait in the dromedary. A good pacing camel can cover the ground with the same speed as many camels do at a canter, since there is less vertical movement, the pacing gait is more energy efficient. There seems a good potential for selection of pacing ability in the camel. With regard to speed in anyone camel, the gallop is faster than the pace, but very few can maintain it for long distances. The mature camel rarely gallops by choice. Juveniles use this during play.

Workers in Abu Dhabi showed that there is a linear relationship between the velocity of the camel and its stride length (SL) and its velocity and stride frequency (SF). It was indicated that in the pacing gait, camels use proportionately greater SL and low SF than horses for a given speed. A study of SL and SF at the end of 6 km races showed that the fastest camels had the longest SL and the lowest SF. The fastest camel had SL of 5.6 m and SF of 1.64/sec at 9m/sec (32.5 km/hour) (Manefield and Tinson, 1997).

Q. Write notes on saddles and harnesses.

Saddles: The design and construction of saddles is influenced by a number of factors such as tradition, social status and materials available and human ingenuity. These are generally based on wooden frames covered with cloth or leather. The quality of padding, tooling and ornamentation generally depends on the social standing of the owner. With racing camels saddle weight is an important consideration. It is usually a rudimentary crescent of padded material so attached to girths as to just prevent it and the rider sliding off backwards. For riding other than racing, some people tuck a folded blanket under the straps. In regions such as Indo-Pakistan, traditional saddles are most often based on a wooden frame. These may be double saddles, capable of carrying two riders, or a rider and his travelling kit. The single hump saddle is generally lighter. In Australia, a modern saddle has been developed using leather over a tubular aluminum alloy frame. This is a double saddle, when properly fitted it is very kind to the camel and the rider. Both riders are provided with stirrups. Whatever the saddle design, one girth is often not enough to keep the saddle from rolling sideways and sliding either forward or backward. An additional flank girth is a necessity with many saddles. These may be stabilised by horizontal linkage to the main girth each side of the hump base. A breast plate and a crupper suitably padded can further stabilise the hump saddle. Long double saddles provide stability by virtue of their design. Saddles for baggage camels may be pieces of wood lashed together by rope. Sometimes pieces of the load may form the frame and the remainder of the load is roped on to them. Whatever the saddle design, material or use, two principles should be kept in mind. All parts touching the camel should be padded in such a way as to prevent abrasion and brushing. The camel is usually working in a hot climate and it does sweat. Therefore, saddle design and fitting should not interfere too much with sweat evaporation.

Harnesses: For draught purposes harnesses are usually made of rope, leather etc. The draught is usually taken from a point in front of withers, that is, above the neck, but sometimes a padded neck collar is used. The low set on of the camel's neck does not lend itself to taking the draught from a breast plate. When ploughing, powering stationary plant and pulling wheeled vehicles as a team, a swingle tree is almost always there to

equalize the pull of the traces. With single harness wheeled vehicles, short traces may be attached directly to the shafts. The shafts are supported from a saddle and breast plate, with crupper, girth and belly band fitted, as for a horse (Manefield and Tinson, 1997).

Q. Write a note on camel marketing.

Marketing channels for camels are not well developed in most of the camel raising countries. Except at two to three places, no specific camel markets exist in Pakistan. Markets of varying duration are held weekly/monthly /annually where marketing of various species of livestock including camels is carried out. Camels are sold for cash in local markets. At markets specifically meant for camels, dealers come from far off places. They strike the bargains in a manner that often favours the middleman and the buyer. The producers get the least. There are various types of market fees and charges (official and unofficial) which the seller and the buyer has to pay, leaving a very small profit margin, especially for the producer. Camel smugglers are always there involved in illegal exports of camels to various countries in the region. They buy the animals at cheap prices and earn a lot of money by exporting at much higher prices. Organised marketing channels for camels should be developed. Middlemen should be license holders and underhand deals should be strictly banned so that the producers get their due share from the sale proceeds. All selling/buying should be done through open auction involving no secret deals. All Tehsil Market Committees should hire an official Auctioneer who should be responsible for all such auctions at any place in a certain Tehsil. Various malpractices in the marketing process deprive the camel producers of a sizeable part of their profit margin. This ultimately keeps the producers from making any supplementary inputs (better feed, health cover etc.) in their animals during the finishing period.

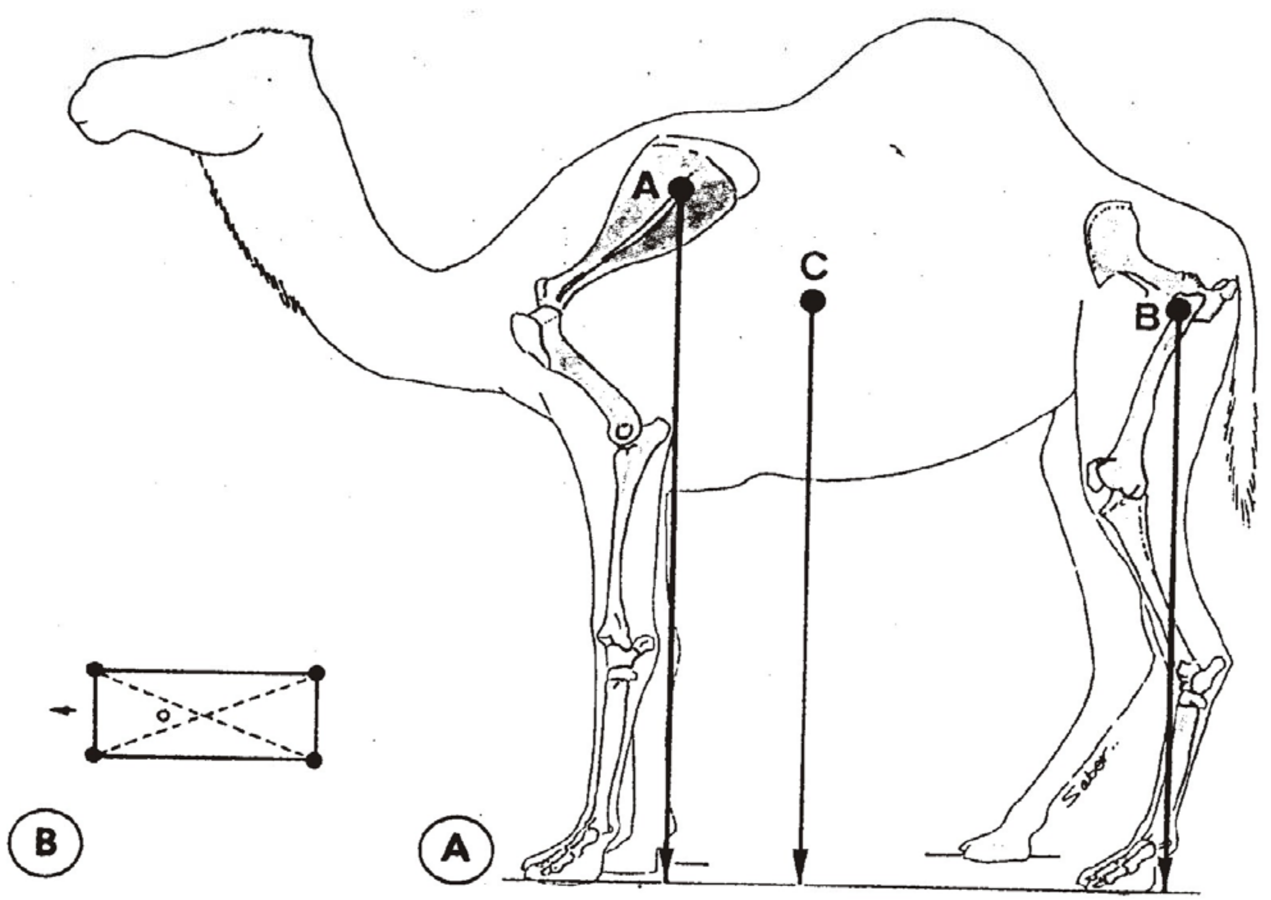

Fig. 29. (A). Points of impact of the shoulder A and hip B joints, and point of center of gravity C in the camel. (B) The rectangle of support for the body's center of gravity in the camel
Source: Saber (2000).

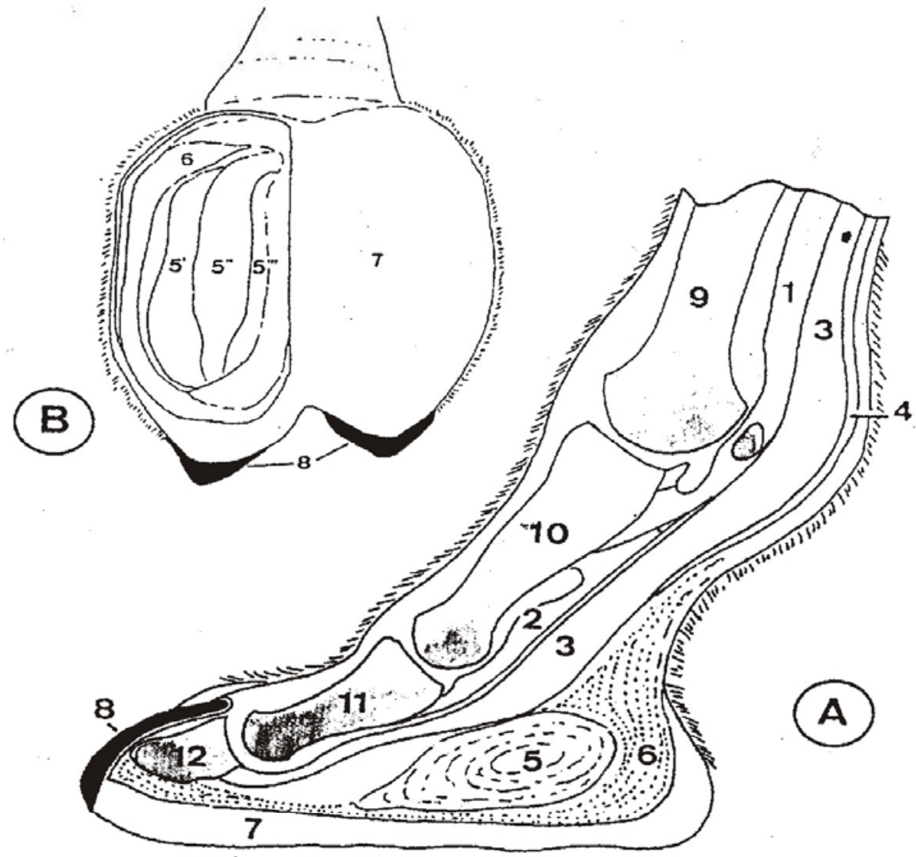

Fig. 30. Longitudinal section of the left medial digit of the camel forelimb (A) and ground surface of the foot pad 2 interdigital septum, 5 adipose-elastic digital cushion, 6 elastic connective tissue (yellow pad, 7 sole, 8 nail, 9 metacarpus, 10 proximal phalanx, 12 distal phalanx
Source: Saber (2000).

HEALTH CARE

Q. Suggest practicable measures to keep camels healthy under field conditions.

Feeding: Camels are adapted to desert plants and shrubs with a high fibre content. As long as they forage freely on range vegetation, they rarely have digestive problems. Problems arise if they are stall fed with concentrates and lack access to roughage. Cut green fodder such as corn, millet, sorghum, legumes, grass and loppings from trees make excellent fodder. These can be supplemented with ground grain, beans and gram; oilseed and oilseed cake; dates and crushed date stones; jaggery and brown sugar or molasses mixed with other ingredients as a tonic.

A typical daily diet for a large (about 600 kg) working camel in Pakistan is 10 to 15 kg green feed or 7 to 8 kg straw or hay, about 2 kg grain and some salt. Some pastoralists offer other feeds to build up a camel's fat store before heavy work or a long journey. Valuable animals such as pregnant milking females, calves, breeding males and working animals need extra feed.

Water: The amount of water a camel needs varies according to various conditions. Camels can go for long periods without water and they generally need less water than other livestock. During the rainy season they can get all the water they need from green fodder given to them. When thirsty, they can drink 80 to 100 litres of water at a time. Different breeds of camels need varying amounts of water. Rendile camels can go 12 to 14 days without water, whereas Somali camels cannot do without water for more than 7 to 9 days. Some pastoralists train their camels to go without water during the dry season for at least 7 days. This enables them to forage further away from the watering places than other livestock.

Salt: Camels require large amounts of salt in their diet. It can be provided by grazing them on vegetation with a high salt content, feeding with additional salt, or by watering them at salty springs or wells. Instead of salt blocks, give loose salt or mix it with water or feed. You may also need to give additional minerals to avoid mineral deficiency.

Deworming: It is a common belief that camels suffer from fewer internal parasites than other livestock because they live in dry areas and they mainly browse from trees rather than graze close to ground. Using water sources that are free from faeces also helps prevent worm infestations. However, if camels are kept in high rain areas or use contaminated water sources, occasional or regular deworming may be useful, but it should be cost effective. Some people recommend deworming calves that are to be sold; others suggest that deworming may interfere with the animal's natural resistance to parasites. Such interference may be a danger if it is not possible to deworm the animals regularly.

Ticks Control: Ticks are a problem in many countries. It is necessary to remove the ticks regularly by hand picking or applying acaricides, especially important for calves. The calf enclosures should be shifted every month and tick infested grazing areas must be avoided.

Prevention of Trypanosomiasis: Preferably do not graze camels in areas with many biting flies carrying trypanosomiasis. Camel pastoralists avoid infested areas during the seasons and times of the day when the flies are most active. Limit the number of fly bites by using fly repellents, especially in the rainy season. Quinapyramine chloride prevents camels from catching the disease; it should be given before or at the beginning of the rainy season. Some workers recommend administering it 3 to 4 weeks after the onset of rains.

Vaccination: Vaccines are available against haemorrhagic septicaemia, haemorrhagic enteritis, blackquarter, pox, anthrax, rabies etc. All animals must be protected against these diseases.

Care of Pregnant Animals and Newborn Calves: Avoid stressing pregnant animals and do not bleed them to obtain food for people (as is done in some pastoral societies). Treat the umbilical cord with iodine/pyodine or another disinfectant. Make sure the newborn drinks the colostrum as soon after birth as possible. Help the calf if necessary. Being rich in antibodies, the colostrum helps build up the calf's resistance to diseases. The colostrum should be undiluted and no other animal should have suckled the mother for several days before the birth. Several herders do not allow the calf to drink the colostrum; this may be one important reason that many calves die. However, drinking too much colostrum may give the calf diarrhoea. Make sure the mother accepts the calf and allows it to drink.

Care of Sick Animals: Keep the sick animals separate from the herd to avoid the disease spreading to other animals. Provide enough good quality feed, clean water (especially for animals with diarrhoea or fever), shade and shelter from the wind. Cover the animal with old blankets during cold nights. Move animals that cannot stand up once or twice a day to prevent sores. Make sure the sick animal gets enough rest; do not move it with the herd and do not use it for work until it has recovered completely. Check on the sick animals regularly. Clean discharge from the eyes, nose and ears and clean wounds and renew the dressings each day.

To reduce the risk of spreading disease, the person who takes care of animals with infectious diseases should not handle healthy animals. A separate enclosure or sick rooms should be built for sick animals. Make sure that the place is free of ticks and that the ground is dry and free of thorns and sharp stones. Take special care of sick calves. Keep them with their mothers if possible, or feed them with milk from a bottle.

Disease Control Under Ranch Conditons: Deworm if the camel does not grow well. Vaccinate against orf using sheep orf vaccine. As a preventive measure inoculate against blackquarter and anthrax. Vaccinate against haemorragic septicaemia if necessary. If necessary, treat against trypanosomiasis. Control nasal bot flies. Well in time treatment of wounds, abscesses and skin diseases is always helpful. Feed appropriate amounts of salt and minerals. Keep detailed records of animal's performance. Brand the camels with their owner's mark and their individual identification number (K. Rollefson *et al.,* 2001).

Q. What criteria can be helpful in interpreting whether an animal is healthy or diseased?

Only a few herds of camels are such that are being kept at ranches or at organized research stations/breeding farms, the rest probably 99% are maintained under primitive management by pastoralists/nomads mainly in remote areas where regular health care centers or proper diagnostic facilities are not available. Under the circumstances, assessment of an animal whether it is healthy or diseased simply on the basis of its appearance might be confusing. For example, hollow flanks, a retracted abdomen and a shrunken hump may indicate a severe systemic illness, but might also be the result of a prolonged dehydration, which is quickly reversed when the animal can drink its fill of 100 to 120 litres of water. Temporary loss of body weight and condition is normal in dehydrated animals, in camel bulls during the rutting season, in lactating females and in animals which are overworked. A gradual but permanent decline in liveweight can be due to old age of the animal. In young animals a prolonged weight loss is always an indication of a chronic generalized disease.

In the process of interpreting signs of disease, it is essential to develop a proper diagnostic routine. This should include an evaluation of the animal's environment, particularly the supply of forage and water. General information on the health history of the herd and that of the individual animal need to be ascertained before a general inspection and clinical examination is undertaken. Most part of an animal's health status is reflected by general body condition, appearance, conformation, posture and behaviour. Weight is characterised by hollow flanks, tucked up abdomen, a flabby hump and in extreme cases muscle atrophy, especially of the hind quarters (Schwartz and Dioli, 1992).

Q. What difficulties may commonly be expected in deciding what disease a sick camel has?

The animal may show only some of the signs of the disease The same disease may produce somewhat different signs in different animals. Different diseases may produce the same signs. A camel may be suffering from more than one disease and the signs may mask or reinforce each other. Camels are generally placid animals, they often do not show much distress, even if seriously ill. Thus the diagnosis gets complicated, especially if the camel suffers from a general, systemic illness that affects its whole body and not one particular organ.

Q. Write down some commonly observed disease signs.

The following signs can be caused by many different types of diseases: Weakness, dullness, tiredness, lack of appetite, lying down at unusual times, fever and rapid heart beat.

When these signs are present, check for other more specific signs that will help you determine the disease and correct treatment. Experience helps a great deal in arriving at the correct diagnosis. Often a major sign is accompanied by several others; taken together, they give you an idea about the disease.

Signs of Fever: High body temperature, fast pulse, sweating, standing with head down and still, dull, watery eyes, off rumination.

Signs of Dehydration: Pinch a fold of skin and let it go; it returns slowly to its normal position.

Signs of Anaemia (loss or lack of blood): Skin inside mouth and nose is pale or whitish, conjunctiva pale.

Signs of Pain: Neck erect and stiff, sometimes quickly lowering and raising the neck, watery eyes, sitting uneasily, shifting body around, grunting when breathing or ruminating.

Certain signs can be seen in normal animals as well as indicate diseased conditions e.g. shrunken hump in females suckling a calf, can also be a sign in mange, trypanosomiasis, internal parasites, teeth problems and chronic stomach and gut diseases. Similarly, grinding of teeth and foam in mouth are normal after eating salt or in male camels during the rut (K. Rollefson *et al*., 2001).

Q. Give some additional information (other than that given under the foregoing question) to further help in determining that the camel is diseased.

The following signs/symptoms do help in ascertaining that the camel(s) is suffering from a diseased condition:

Reluctance to move, adoption of specific postures, restlessness, vocalization such as grinding of teeth or grunting at certain movements indicative of painful conditions. Painful extremities may result in resting of limbs, frequent shifting of weight from one limb to the other. Grunting when rising or sitting down may either indicate abdominal pain or a traumatized pedestal pad. An extended neck together with strictly abdominal respiration, dilated nostrils or open mouth breathing point to acute chest pain.

Animals suffering from prolonged illness appear dull and do not respond well to external stimuli. When sitting the head is more often extended forward and rested on the ground than usual. Normal grooming such as sand or clay bathing, rubbing and scratching is reduced or completely lacking, resulting in a soiled and dull appearing hair coat. Due to their reduced activity the animals are quite often covered by abundant flies, other insects and tick birds. Excessive grooming behaviour, on the other hand, is usually caused by ectoparasites or by allergic and irritant contactants such as insect stings, plants and drugs. Excessive grooming can result in localized hair loss and inflammation of skin.

Q. Suggest an appropriate protocal for routine clinical examination of the camel.

Although the protocol given below is not specifically pertinent to the camel yet it can provide some useful information for further exploration of the disorder in the camel (Table 27).

Number of days since last watering can be an essential aspect of judging the animal's condition.

Table 27. Procedure for a clinical examination of camels

General information	herd, animal identity, sex, age, weight
Main symptoms	Descriptive
Appetite	Descriptive
Last watering	

Rectal temperature	morning, evening
Respiration	
Frequency	
Quality	laboured or free
Pulse	value, regular, irregular
Mucous membranes	pale, pink, red, haemorrhages
Palpable lymph nodes	
Stomach motility (rectal palpation)	
Faeces	
Consistency	pellets, shaped, unshaped, liquid
Colour	
visible parasites	descriptive
Urine	
Quantity	
Colour	
Discharges	quantity, colour, consistency
Eyes	
Nostrils	
Mouth	
Vagina	
Miscellaneous	

Source: Schwartz and Dioli (1992).

Q. Give normal values for physiological parameters in resting adult camels. Also indicate that under what conditions physiological increase takes place in these parameters.

Normal range of values for physiological parameters in resting adult camels is:

Temperature	:	35.5 – 41.0°C	Respiration	:	5 – 12/min.
Morning	:	35.5 – 37.5°C	Pulse	:	35 – 50/min.
Evening	:	39.0 – 41.0°C			

Besides pathological conditions a variety of environmental and host factors including age, sex, ambient temperature and watering, stress and physical work out have an effect on these parameters. A physiologically increased respiration rate, pulse rate and body temperature can be seen in young animals, stressed and frightened animals, during the rutting season, after physical work out and at high ambient temperatures.

Q. Can body temperature, respiration rate and pulse rate of the camel provide some guidelines in respect of body disorders?

Body Temperature: Camels show a marked diurnal fluctuation of body temperature. The range of normal values is 35.5 to 41.0°C (morning 35.5 to 37.5°C; evening 39.0 to

41.0°C). High temperatures during the morning are indicative of fever. Accompanying symptoms are hyperlacrimation, increased respiratory and pulse rate, loss of appetite, dull and depressed appearance, decreased urine production and later rapid weight loss.

Pulse Rate: Intermittent irregular pulse is not uncommon in camels and is not always a sign of illness. In adult camels pulse rate can be best checked in sternal position. Several arteries including the posterior tibial, middle sacral and the femoral artery are equally accessible. Matted hair and dirt crusts on the hind legs make pulse detection difficult when using the posterior tibial artery. Attempting to use the femoral artery requires patience since the animal might object to the presence of a hand there. In young and immature camels the tail artery is the most convenient.

Respiration Rate: Camels are obligate nasal breathers of a pronounced abdominal respiratory type. Open mouth breathing is always an indicator of discomfort, stress or illness. Respiratory rate is best established by watching flank movements from a distance or by thoracic or tracheal auscultation using a stethoscope. Laboured breathing, coughing and snoring are always indicative of respiratory diseases. Coughing occurs more often during the night or after resting when the animal rises. Nasal and/or ocular discharge is frequently seen in the case of fever, local irritation and inflammation due to parasite infestation, frontal sinus infection, ocular diseases and upper respiratory diseases.

Q. Give the procedure for taking the body temperature, pulse (heart rate) and for measuring the breathing rate.

Body Temperature: Tie one end of a string to the thermometer and the other end to a clothes-peg. Shake the thermometer to bring the mercury level below the normal temperature of the animal. If necessary, grease the thermometer with vaseline. Preferably take the temperature when the animal is sitting and is restrained well by its handler. Hold the tail firmly or tie it to the side and insert the bulb of the thermometer 3 to 5 cm into the rectum. Clip the clothes-peg to the hair at the base of the camel’s tail to prevent the thermometer from getting lost. Leave the thermometer in position for about 3 minutes. Take the thermometer out and read the temperature. Shake the thermometer again to bring the mercury back into the bulb, then clean it and put it back into its case.

The normal temperature is 37.5°C, but a camel’s body temperature varies up to 6 degrees (34.2 to 41°C) during the day. It is low in the morning and higher in the evening. This variation is larger if the animal has not been watered for many days. The body temperature tends to be higher in young camels and in pregnant and lactating females (The normal body temperature of humans is 37°C). Signs of fever include dull and half-closed eyes, water running from the eyes, increased pulse and breathing rate, loss of appetite and reduced urine and milk (in females).

Pulse Rate (heart rate): You can feel a camel’s pulse with your fingers: on the underside of the tail, near the base (only in young animals); inside the hind leg, about 18 cm above the point of hock (although this location may be dirty and crusted with urine); behind the knee on the front leg (least chance of being kicked). You can also listen to the heart rate with a stethoscope in the armpit (in the angle behind the front leg.). A healthy camel’s heart beats about 30 to 50 times a minute, slower than human beings (60 to 70 times a minute). If the camel has fever, the pulse becomes hard, fast and wiry.

Breathing Rate: To feel the breathing, put your hand against the side of its body, behind the ribcage, particularly the right side. Measure the breathing rate while the camel is at rest. Healthy camels breathe silently and barely noticeably, except after physical exertion. A healthy camel at rest breathes 5 to 12 times a minute in cool temperatures, and 8 to 24 times a minute on hot days. Young camels under 3 months of age breathe 14 to 16 times a minute. An adult human breathes 10 to 12 times a minute.

Q. Do you think peripheral lymph nodes can provide some clue about the systemic infection in the camel?

Yes, palpation of peripheral lymph nodes as shown in Figure 31 can lead to the detection of infection in camel. Temporary swelling of peripheral lymph nodes is most commonly due to localized or systemic infections. The site of infection and peripheral lymph node reaction correspond. In systemic diseases all lymph nodes may be affected. The swollen lymph nodes may be tender to touch, hot and the overlying skin oedematous and reddened. Increased sensitivity to touch and warmth is indicative of active infection. In the process of healing, large lymph nodes do regress in size, however, not to their original size and are insensitive to touch.

Q. Write short notes on abdominal examination and rectal palpation.

Abdominal Examination: Stomach motility in camels is different from that of true ruminants, consisting of a total of 12 contractions per cycle. A typical motility cycle is 4.5 minutes long, including a pause of 2.5 minutes. About 2 to 3 audible contractions per minute can be noted when auscultated on the left flank. Passage of a stomach tube for taking samples of stomach fluid and particles is possible in camels.

Rectal Palpation: Rectal palpation should be done in sternal recumbency. In camels the rectum is quite tight and fragile. Preferably the examiner should have small hands and use sufficient lubrication to reduce risk of rectal perforation. Bladder, large intestines, left kidney and the female genital tract can be palpated. Reliable pregnancy confirmation is possible from the late second month of pregnancy onwards. A prominent corpus luteum can be felt and the left horn is markedly increased in size compared to the right one. Reaching left ovary can be sometimes very difficult.

Q. Write short notes on salivation, urination and defaecation as to the guidance that can be obtained from these phenomena in the process of diagnosis.

Salivation: Excessive salivation in camels is unusual. Increase in salivation is suggestive of plant poisoning, snake bite, facial paralysis and central nervous disorders such as rabies. In bull camels during rutting season, excessive salivation is an essential part of the mating behaviour.

Urination: Camels frequently urinate and defaecate especially after rising. Daily output of urine ranges between 0.5 to 5.0 litres/day, depending to a large extent on the camel's status of hydration or dehydration. The colour is usually light yellow but can turn dark yellow during dehydration.

Faeces: Faeces are usually well-formed pellets of light to dark brown colour. In the early rainy season, faeces may take a light green colour, become less well formed or even take a liquid consistency, depending on the water content of the available forage. During prolonged water deprivation, faecal water content may drop to approximately 30%.

Faeces are best sampled by free catch, which is not too cumbersome since camels tend to drop some pellets every few minutes. Grab sampling from the rectum is also easy. Urine collection likewise is best attempted by free catch. Female camels can be catheterized, but their urethral opening is small and a suburethral diverticulum just in front of urethral opening makes insertion of a catheter quite difficult. Male camels cannot be catheterized due to the presence of a urethral recess at the ischiatic arch.

Clinical Aspect: Body fluids and excretions such as saliva, urine and faeces can change in colour, volume, frequency of excretion, consistency and smell, which often points to specific disorders. A dark reddish to dark brown discolouration of urine indicates the presence of blood, myoglobin or haemoglobin. This is a serious clinical finding, just like a black and tarry appearance of the faeces caused by occult blood. The claim by many East African pastoralists that they can diagnose acute phases of trypanosomiasis by the smell of the animal's urine, was found fairly accurate by the scientists working in that area.

Q. Write a note on blood collection from the camel.

Usual convenient sites for blood collection from camel are the jugular vein, the medial volar metacarpal vein and the dorsal metatarsal vein. Veins are either raised by digital pressure or using a tourniquet. Total blood volume in camels is 93 ml/kg body weight. Camels have large oval shaped erythrocytes. These may rupture when blood is transferred from a syringe into a vacuum sampling container too rapidly with too much pressure on plunger, thus giving a faulty diagnosis. Measurement of haematocrit values in camels is not as valid an indicator of the health status since the normal range is very large. Haematocrit values ranging from 18 to 42 have been measured in the same animals within a time span of 10 days at various stages of mild dehydration.

Q. How would you proceed to collect various types of samples for diagnosis of certain diseases in the camel?

If there is some confusion or uncertainty that what disease is making an animal sick and if a laboratory is nearby, take a sample and send it to a laboratory for testing. The causes of diseases such as rabies, anthrax and trypanosomiasis can be identified for certain only by laboratory tests. Depending on the problem you can collect samples of the camel's blood, faeces, urine, skin and hair, foetus and placenta and body tissue.

Blood and organ tissue samples can be taken from a newly dead animal to find out why it died. This should help to prevent other animals from getting the disease. Sample should be taken as quickly as possible, but if taken more than 12 hours after the animal has died, there is less chance that tests will yield useful results. If the sample is to be used to test for bacterial diseases, the equipment and containers you use must be sterile. For other diseases, it is enough to make sure that the equipment and containers are clean.

Dangerous Diseases: Some diseases are dangerous for people. Do not allow these tissues or the blood to touch your skin. Wear gloves or plastic bags on your hands and wash your hands and clothes immediately afterwards. Dispose of the infected tissue by burning it. If there are any bloody discharges from the nose, mouth or anus, do not take samples or cut open the carcass to examine it. The animal may have died of anthrax, and

opening it may allow the spores that cause it to escape and contaminate the surroundings, and may expose you to infection by this deadly disease.

Labelling Samples: After collecting the sample, write a simple code (A, B, C etc.) on the bottle or bag. Write the following information on a separate piece of paper so that it is easy to refer to in the lab.:

The code for the sample (e.g. A, B, C), the type of sample (e.g. serum, urine, part of the body the tissues came from), the date the sample was taken, name or ear-tag of the animal and name and address of the owner. The disease you suspect and the type of test you suggest should be done. The history of the disease: signs of the disease, how many animals are affected, how long the disease has lasted, any recent changes (such as changes in grazing, feeding or newly introduced animals) and your own name and contact details.

Storing and Transporting Samples: Some types of samples must be kept cold or they will decompose and become useless for testing. Put them in a jar with a screw-top lid and keep them with ice or in a refrigerator. If you need to transport the sample, pack the containers in ice (in a flask or in an insulated picnic box) and make sure the ice is renewed if necessary on the way to the lab. During transport, pack the sample tightly and with plenty of absorbent padding so that the containers cannot move around or break and liquid cannot leak out.

Dried Blood Film: It is used if you need just a few drops of blood, for example to check for trypanosomiasis. Just nick the edge of the camel's ear with a pair of sharp scissors and squeeze the blood out, a few drops directly onto a clean microscopic slide. Place the straight edge of another clean slide at an angle of 30 to 40° on the lower slide, just in front of the blood drop. The drop will spread along the bottom edge of the upper slide. Glide the upper slide evenly forward to form a thin, uniform film on the surface of the lower slide. Prepare two slides from each blood sample in this way. Allow the blood to dry in a shady, dust free place. Make at least two slides for each animal. Send these slides to the lab. Label and pack them carefully, face-to-face, with matchsticks between them to prevent the dried surfaces from touching.

Whole, Unclotted Blood: It is used to test for trypanosomiasis and whether the animal has an infectious disease. Use a syringe needle to take a sample of more than a few drops of blood. Normally, blood clots quickly when the air touches it. To stop it from clotting, you must use an anticoagulant such as EDTA or heparin. Prepare the blood container by putting a little anticoagulant into it before collecting the blood. For trypanosomiasis tests, the container must be clean, not necessarily sterile. For other types of tests, make sure it is sterile.

Restrain the camel to prevent it from moving. Tie a rope tightly around the camel's neck. Raise the head with the neck straight in front of the body, not bent to one side. Feel for the jugular vein at the side of the throat. You should be able to feel the elastic bulge of this vein about one hand's width from the head. Insert a sterile syringe needle into the vein. Hold a small, clean jar or tube containing some anticoagulant under the needle to catch the blood that comes out. Hold the jar as close to the needle as possible and let the blood run along the inside of the glass without splashing. Catch about 10 ml of blood.

Stopper the jar and turn it upside down several times to mix the blood and anticoagulant. Do not shake it vigorously; it may damage the sample and make it useless. Carefully pull the needle out and loosen the rope. To stop any bleeding, press your thumb for a few minutes on the skin where you had put in the needle. Keep the blood in a refrigerator (4°C, not frozen) until it can be tested.

If a sterile blood sample is needed, attach a sterile syringe to the needle before putting the needle into the vein. Collect the blood in the syringe, then inject it slowly through the rubber stopper into a sterile tube containing an anticoagulant. A special tube called a 'Vacutainer' can also be used. It is a sealed sterile tube with a vacuum inside. When the vacutainer needle is pushed inside the vein, the vacuum inside draws in the blood. Vacutainers come with an anticoagulant already inside to prevent the blood from clotting. Using vacutainers is easy and avoids the risk of contamination.

Blood Serum: It may be used to test for mineral deficiency and infectious diseases such as brucellosis. The clear liquid that separates from the blood when it clots is called blood serum. It is needed to test for antibodies in case bacterial or viral infections are suspected or to analyse the blood chemistry.

Collect the blood from the jugular vein as described under Whole, Unclotted Blood above, but without adding any anticoagulant. Put the blood into a sterile stoppered tube or jar. Put the container in the shade or in the refrigerator and leave the blood to clot for 2 to 3 hours. Loosen the clot from the wall of the container using a sterile needle. Carefully pour the serum (the clear, yellowish liquid) into another sterile container, leaving the clot behind. Store the serum in a refrigerator (4°C) or freezer (-20°C) until it is tested.

Faeces: It is used to test for intestinal worms and liver flukes. Turn a clean plastic bag inside-out and put it on your hand like a glove. Put the bag-covered hand gently into the animal's anus. Grab some droppings from inside the anus and bring your hand out. Only about 10 g of faeces in needed for most tests. Turn the bag the right way round so that the droppings are inside it. Tie the neck of the bag close to keep the faeces in, or put them in a clean, airtight container. Label the bag or container and send it to the laboratory. Keep it cool so that the parasite eggs do not compose or develop into larvae, which are difficult to identify.

Urine: It may be used to test for kidney diseases and the cause of red urine. When the camel passes urine, let the first part of the urine pass. Catch the middle part of the urine stream in a clean, wide-mouthed screw-capped jar. Screw on the lid. If it will take more than 4 hours before the sample can be tested, freeze it as soon as possible.

Skin and Hair: These can assist in testing for mange and ringworm. Scrape the affected skin carefully with a new scalpel. Scrape from the edge of a sore or from a fresh sore, not an old one. Scrape until some blood oozes out of the skin. Let the skin and hair drop into an envelope, jar or small, clean plastic bag. Collect scrapings from three different places.

Foetus and Placenta: These are used to test for brucellosis. Keep in mind the precautions described under 'Dangerous Diseases' above. Dissect the freshly aborted foetus. Collect the fluid inside the foetus's stomach with a sterile syringe. Put it into a sterile stoppered jar or tube. Seal the jar with paraffin wax to prevent bacteria from getting in. Collect fluid from the placenta in the same way. Put it in a separate jar and seal

it with paraffin wax. Put the placenta in a plastic bag and tie it securely. Wrap it well to make sure that no leakage takes place. Put all the samples in a refrigerator until they can be tested.

Body Tissue: A specialist may need to check certain body parts under the microscope for infection. You may be asked to provide a sample of that body part (e.g. a piece of dead camel's lung). If a dangerous disease is suspected, use the precautions given under dangerous diseases above. Cut open the carcass to reveal the organ or body part you need. Cut into the tissue as cleanly as possible using a sharp knife. Cut blocks of tissue about 5 cm across. Put the tissue into a clean, dry jar with a screw lid. Put the jar into a refrigerator until its contents can be tested (K. Rollefson *et al.*, 2001).

Q. Discuss the various methods and modes of administering drugs to camels.

Oral application of drugs is done by drenching, through bolus or medicated feed. Drenching and bolus administration are best accomplished with the animals seated, the head is then immobilshed and tilted slightly backwards and the liquid medication poured onto the back of the tongue. Boluses (boli) and tablets should also be placed on the tongue as far back as possible. Medication of feeds is rarely done since most camels have to find their feed on pastures. One exception is the dosing of granulated mineral mixtures with anthelmintics, which has become a proven practice.

The same hygienic care and sterilization procedures have to be observed in injecting drugs to camels as in all other livestock. For subcutaneous injection the preferred site is just in front of the shoulder. This is one of the few sites on the camel's body with the skin loose enough to be grasped and lifted. A needle without syringe attached is inserted under the skin, which should be easily moveable underneath. In suction no blood should appear in the hub of the needle. If accidentally a blood vessel is hit, the needle needs to be repositioned. Then the drug is injected and the needle still attached to the syringe is withdrawn. Injected volumes should not exceed 50 to 100 cc per injection site.

For intramuscular injection, the usual sites are the neck and gluteal muscles. The needle should be placed firmly and deeply into the muscles. The syringe is then attached and the drug injected. If a blood vessel is punctured the needle has to be repositioned. Injected volumes should not exceed 15 to 20 cc per injection site. For intravenous injections, jugular vein is considered the most common and convenient site. Camels have a very large jugular vein, which can be easily raised by palm pressure in the cervical groove. For raising the vein, a tourniquet can be applied near the base of the neck. When the needle has been inserted, the pressure is released or the tourniquet loosened and the drug is injected slowly and steadily. After drug administration the needle attached with the syringe is withdrawn. Simple digital pressure for a short period of time or the application of an antiseptic adhesive tape in case of blood leakage from the puncture will stop the bleeding. Caution is advised for restraining rutting bulls for blood sampling or intravenous drug administration, since there is a high risk that they injure their dulaa by biting on it.

Q. What do you understand by good nursing care as applicable to camels?

The importance of good nursing care for successful treatment of any given disease cannot be denied. However, the original habitat of camels and the production systems where

most of the camels are normally kept, are not conducive to the application of a desired nursing programme. There are, nevertheless, some measures, which can be adopted under most circumstances. For example, weak and debilitated animals should be kept separate from the rest of the herd and given some supplemental feeding. Their enclosure should provide some shade and be sheltered against wind. Recumbent weak animals should be shifted once or twice a day to reduce the risk of sores. They should be watered daily, especially when running a high temperature or have profuse diarrhoea. When branches cut from trees are fed, they should be tied to a post or tree so that the camels can pull the leaves off. Wounds should be looked at daily and cleaned if necessary. The same applies to discharges from eyes, ears and mostrils. Animals having contagious disease should be treated and kept in sick rooms always away from the rest of the stock. The person handling such animals should not handle healthy animals. Close monitoring of sick animals and daily evaluation of their condition should be done as a necessary routine during any given treatment (Schwartz and Dioli, 1992).

Q. Write a note on the use of curative drugs in camels.

Most of the information regarding efficacy and dosage recommendations for antimicrobial and antiparasitic drugs commonly used in camels is based on clinical use. The dosages have been usually derived by extrapolation from those recommended for other large species such as the buffalo, cattle and horse. Some local drug manufacturers do recommend now dosage for camels. However, while using new drugs, species differences may result in prolonged withdrawl periods, adverse reactions such as local tissue irritation and toxicity. An example is the trypanocide Berenil, which is widely used in cattle, is fatal for camels, causing death within 15 minutes after application.

The ability of the camel to adjust its body water content to longer periods of water deprivation, shows that probably pharmacokinetics of drugs, which are predominantly excreted by the kidneys, will differ significantly from what is known for other domestic species. Therefore, frequent watering or preferably free access to drinking water should be an essential part of all repeated or prolonged drug treatments of camels to prevent accumulation of drugs or their metabolites in body tissues.

Q. Give a brief account of traditional treatments used by camel herders/pastoralists to cure various diseased conditions.

Schwartz and Dioli (1992) have reported that camel herders/pastoralists have adequate awareness about common ailments of their animals and diagnoses made by them are mostly correct. Local languages in various camel-raising areas have extensive vocabulary on diseases and health conditions. There is also a wide range of treatments, which include herbal preparations for oral administration, ointments, rinses and disinfectants for external application, branding for curative purposes and treatments for wounds, abscesses and fractures. Some of these are applied very effectively. Various ingredients used in herbal preparations are locally available and more important that they are cheap.

Branding is the most widely and frequently applied treatment. It is used against a wide range of conditions, but mainly against swollen joints, stiffness and lameness, general musculo-skeletal faults, pneumonia, swollen and suppurating lymph nodes and abdominal oedema. The main effect is enhancing localized blood flow, thereby aiding in

healing process in cases of localised infections and inflammations. The branding is normally applied extensively in lines, circles and points. Thus branding camels here serves more than one purpose i.e. for identification, as a curative measure and for decoration of the animal.

Q. What does a ‘drip’ mean? What equipment is needed to give a drip?

A ‘drip’ is a large amount of liquid, injected slowly into the vein. Drips are used to treat animals that have been severely dehydrated due to diarrhoea or other causes. You will need a bottle(s) of the intravenous liquid, a special flexible plastic tube with a drip and hollow needle at one end and a clamp in the middle and two sterile syringe needles (one of which must fit on the end of the tube) (Figure 32). Give a drip in the jugular vein (K. Rollefson *et al*., 2001).

Q. What are the various types of anaesthesia?

There are three types of anaesthesia.

General Anaesthesia: It makes the animal lose consciousness and stops it from feeling pain anywhere in the body.

Regional Anaesthesia: It stops pain in a part of the body, while the animal stays conscious. It is used for surgical procedures in the genital area such as prolapse of the vagina or uterus. Do it by injecting a local anaesthetic into the spinal cord.

Local Anaesthesia: It stops pain only in the area where it is injected. It is used for suturing wounds and for minor operations.

Q. Discuss in detail chemical restraint and general anaesthesia in camels, including important drugs used for the purpose.

In rare cases camels become aggressive and cannot be approached easily to administer drugs or to take blood samples. In such a situation chemical immobilization may be necessary. Several injectable drugs and inhalant anaesthetic agents such as Halothane and Isofluran have been successfully used in camels. General anaesthesia using these agents is not suitable for field or on-farm use.

Table 28. Drugs commonly used and their dosage for sedating and immobilizing camels

Name	Dosage (mg/kg body weight)	Application	Effect
Xylazine[1)]	0.25 – 0.50	1M	Sedation 30-60 minutes
	1.0 – 2.0	1M	Anaesthesia 90 minutes
Yohimbine	0.125 – 0.25	1M	Antidote
Propionyl-promazin[2)]	0.2 – 0.5	1M	Sedation 2-4 hours
Ketamine[3)]	5.5	1M	Sedation 20 minutes
Chlorpromazine + pentazocine	2 + 2		Anaesthesia
Detomidine	50		Sedation

Thiopentone	10.35 ± 0.64		Anaesthesia 30 minutes
Ketamine/Xylazine	1 – 2	1M /1V	Anaesthesia 30 minutes
Etorphine[4)]			
adult animal	0.25 – 0.5*	1M	Immobilization
young animal	0.1 – 2.0*	1M	Immobilization
Diprenorphine	2 x dose etorphine	1M/IV	Antidote

* mg/45 kg body weight.
Source: Schwartz and Dioli (1992).

1) Rompun (Bayer) is the first choice as a sedative drug for camel. It effects good muscle relaxation and has a slight analgesic effect. Its effect appears 15 minutes after IM injection and is indicated by a pendulous lower lip, closed eylids, increased salivation and bradycardia. Higher doses (Table 28) may be required in excited animals. There is considerable risk of abortion in late-term pregnancies. Atropine sulphate is given at a dose of 0.01-0.02 mg/kg body weight IV to counteract bradycardia and increased salivation. Doxapram hydrochloride or Dopram V (Willows Francis) a strong CNS stimulant, has been used effectively at a dose of 0.05 to 0.13 mg/kg body weight IV to hasten arousal and counteract respiratory problems.
2) Combelen (Bayer) produces sedation with moderate muscle relaxation, but without analgesia. There is also a strong sympatholytic effect, which can cause circulatory problems and possible paradoxical reactions. The onset of effect takes 20 minutes after injection and is indicated by general sedation and marked tachycardia.
3) Ketanest (Bristol Laboratories) and Vetalar (Parke Davis) cause dissociative anaesthesia with good analgesic effect, amnesia and increased muscle tone. Excitement, convulsions and apnoe may occur shortly after injection, especially after IV injection. Onset usually takes place after 10 minutes. Under Ketamine eyelids stay open, an application of eye ointment is recommended to prevent drying of the cornea during prolonged procedures. A marked tachycardia is noticeable.
4) M99 and M50:50 (American Cyanamid), large animal Immobilon and Revivon (C Vet) are very potent narcotic analgesics. They are extremely dangerous for people to handle. Cutaneous or mucous contact, inhalation or accidental injection of minute amounts can be fatal. It is mandatory when using etorphine that Naloxone, the narcotic antagonist, has to be at hand for immediate administration in case of accidental contact. Camels under etorphine immobilization show severe muscle rigidity, muscle tremors, tachycardia and respiratory depression.

Q. Discuss briefly what needs to be done before and after sedation of a camel?

Do not allow the camel to eat for 24 to 36 hours and prevent it from drinking for 12 hours before the operation so as to make sure that it does not vomit and is not choked by the rumen contents. Before injecting the sedative make the camel sit down and restrain it so

that it cannot get up. Some body needs to hold its head to avoid moving it violently. After giving the injection do not disturb the animal until the sedative has taken effect.
If the camel has become completely sedated, bring it back into a sitting position before it wakes up. Tie its head down until it can hold it up by itself. Do not loosen the ropes until the camel is ready to get up by itself. Once it stands up, it may sway and reel, so you may have to support it by holding the halter and tail.
Drugs for Sedation: Xylazine (Rompun) is commonly used for sedation. It is available as a 2% or 10% solution. It is injected IM but can be given IV. Xylazine also reduces pain and partly relaxes the muscles. The dosage has been shown below:

Dosage of xylazine	**Duration of effect**	**Purpose**
0.25 to 0.5 mg/kg IM	30 to 60 min	Minor operations
1 to 2 mg/kg IM	90 min	Immobilization, castration

The sedative usually starts taking effect about 10 to 15 minutes after it is injected. Do not disturb the animal during this period. When sedation starts the camel drops its lower lip and closes its eyes. It starts drooling and its heart slows down. The effect of xylazine can be reversed by injecting Antagonil (Yohimbine HCL) at a dose of 0.25 mg/kg body weight IV.
Propionylpromazine (Combelen): It is used at a dosage of 0.2 to 0.5 mg/kg IM. Apart from sedating, it also acts as a slight muscle relaxant. Since it does not reduce pain, therefore, cannot be used for surgical procedures. Sedation starts 20 minutes after its injection and then lasts for 2 to 4 hours. Its side-effects include increased heart rate and seizures.
Diazepam (Valium): It can be injected IV at a dosage of 200 to 300 mg. It tranquillizes the camel for 30 to 40 minutes. Half this dose is required for young animals. It does not relax the muscles. Do not use in pregnant animals.
Painful Surgical Procedures: Xylazine combined with Ketamine (Ketanest, Vetalar) can be used for painful procedures. In combination they provide a stronger effect against pain. Xylazine should be given 15 minutes before Ketamine. The dosage is 0.4 mg/kg Xylazine and 2.0 mg/kg Ketamine IM. The camel stays drowsy for up to 2 hours.
Epidural Anaesthesia: It is used for surgery in the genital area e.g. for prolapse of the vagina or uterus.
Move the camel's tail up and down and feel where the rigid backbone ends and the tail (which can be moved) begins. The gap between these bones is where to give the injection. Clip the hair, clean and disinfect the skin. Insert a 20 gauge 4 cm needle at right angle to the tail. The needle must go between the bones into the spinal canal. Slowly inject 2 to 5 ml of lignocaine. This will stop pain in the genital area for about 2 hours. Epidural anaesthesia should be given only by an experienced person (K. Rollefson *et al.*, 2001).
Local Anaesthesia: Use lignocaine hydrochloride (Lidocaine)

Q. Give normal levels for commonly measured serum constituents in adult camels.

Alkaline phosphatease (ALP) and creatine kinase (CK) levels are different in very young animals. At birth ALP is 2000 to 3000 U/l and CK 200 to 400 U/l. At 10 days age the ALP was 200 to 400 U and CK as for the adult. By 28 days age, the neonate had both ALP and CK values similar to that of adult camels. Other pertinent biochemical values in young camels do not differ significantly from adults. These values have been measured by two different batch analysers (Table 29).

Table 29. Commonly measured serum constituents in adult camels using two different batch analysers

Constituent	Roche Cobas Mira	Dupont dimension
Total protein	5.5 – 7.5	5.2 – 6.9 g/dL
Albumin	3.0 – 4.5	2.5 – 3.9 g/dL
Globulin	1.0 – 4.5	1.3 – 4.3 g/dL
Urea (blood urea nigtrogen)	3.0 – 9.7	1.5 – 11.9 mM/l
Glucose	3.0 – 11.6	3.7 – 11.1 mM/l
Creatinine	98 – 150	100 – 230 µM/l
Iron	58 – 154	57 – 130 µg/dL
Lactic dehydrogenase	500 – 1450	250 – 556 U/l*
Alkaline phosphatase	80 – 120	80 – 120 U/l*
Aspartate aminotransferase	42 – 154	40 – 165 U/l*
Glutamyl transferase	0 – 20	0 – 40 U/l*
Creatine kinase	0 – 240	14 – 100 U/l*
Na	145 – 157	133 – 159 mM/l
K	3.4 – 6.2	2.9 – 5.9 mM/l

Source: Manefield and Tinson (1997).
* = International units per litre.

Q. Give an outline of picture of red cells and white cells in relation to camel blood.

The RBCs (erythrocytes) are ovaloid and possess unique properties. They are fairly flat and non-nucleated. Their dimensions are: long axis 7.7 to 10 µm, short axis 4.2 to 6.4 µm, thickness about 2.5 µm, surface area 50.6 µm² and a reduction in area may take place after 7 days water deprivation to about 37.3 µm². Dehydration does not change the shape of the cell, but rapid rehydration causes them to become rounder/spherical in shape 4 hours after a massive drink. Compared to other species, the camel erythrocytes exhibit great resistance to osmotic change. Possibly the shape of the cells may play a part in this phenomenon. This resistance appears to increase in the early dehydrated state and returns to normal after about 7 days of water deprivation. This partly explains why the camel can safely rehydrate very rapidly by drinking large volumes of water. Intravascular

haemolysis due to hypotenicity does not appear to occur in camels. Human red cells lyse in 0.5% saline, while camel cells remain intact in 1.2% saline. They are probably the most resilient erythrocytes known. They are also reported as being resistant to the lytic effect of snake venom. As to the effect of increasing concentration of saline solution, it is only when concentration reaches 20% that the majority of the cells will be seen to be abnormal. Human cells show complete crenation (abnormal notched appearance of erythrocytes) in 1.5% saline.

The red cell count in camels has been reported as 4.2 to 12.5 x 0^{12}/l. A seasonal variation in count has been reported in sedentary as well as racing camels, being lower in summer than in winter. It could be a physiological adjustment in summer aimed at lowering blood viscosity to assist circulation and hence heat exchange during the hotter months. Due to the camel's ability to maintain plasma volume even after 7 days water deprivation, no consequent raise in RBCs has been reported. In contrast, a decline in RBC count of about 30% has been reported within a few hours after rapid rehydration. The haematocrit value (PCV) in racing camels ranges from 25-35%, being about 2% lower in sedentary camels. In contrast to other species, dehydration causes no increase, but a little decline in PCV in camel. This is because of water drawn into the vascular compartment from the alimentary tract. Increases of 4 to 8% in PCV can be seen when samples are first drawn quietly in the camp compared to those taken when the camel is moved to the racing track and the samples drawn pre-and/or post exercise. Excitement induced spleenic contractions do not influence RBC values as much in the camel as they do in the horse. Erythrocyte survival time is approximately 90 days in winter and 120 days in summer.

The packed cell volume (PCV) in the camel can be read with an haematocrit running at 1400g's for 5 minutes. Resting PCV is low in the camel compared to other athletic animals such as horse (40-45%) and dog (57-62%). Automated counters may only produce the same result plus/minus 1%. New technology is becoming available. It can better cope with a spectrum of species. Haemoglobin is 136g/l (horse 110-190, dog 190-210 g/l).

White blood cell (WCC) count in the camel is relatively high 11.9 ± 2.9 X 10^9/l. For practical purposes a range of 8 to 18 X 10^9/l can be used. Normal differential count is: neutrophils 40 to 60%, lymphocytes 40 to 60%, eosinophils <6%, monocytes <4% and basophils are rarely seen. Usually neutrophils exceed lymphocytes. A study at the SCRC by Manefield and Tinson (1997) showed that neonates had a white cell picture different to that of adult camels. At day 1, WCC was 18 to 22 x 10^9/l, with a differential showing neutrophils 75 to 80% and lymphocytes 20 to 25%. At day 10, WCC was increased by 10 to 15% and differential count remained almost the same as at birth. At day 21, WCC was the same as on day 1. At day 28, WCC had fallen to 17 to 22 X 10^9/l.

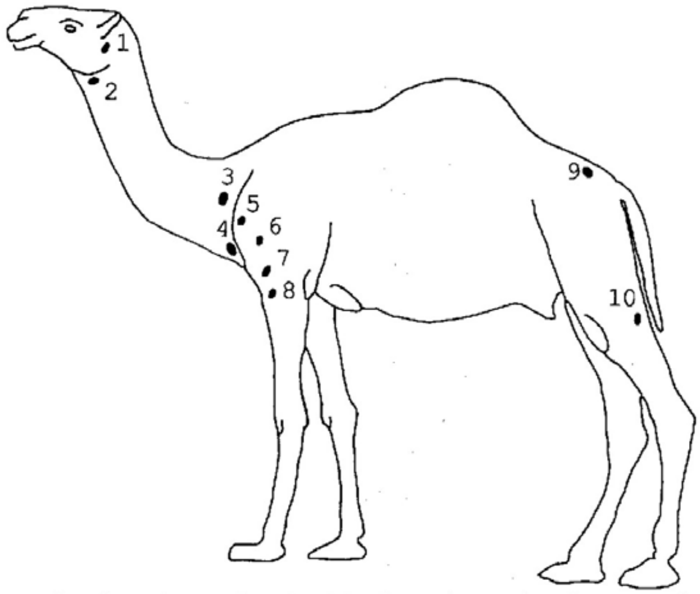

Fig31. Schematic drawing of palpable lymph nodes in camels: 1 preparotid, 2 pharyngeal, 3 prescapular, 4 inferior cervical, 5+6 external thoracic, 7 pectoral, 8 cubital, 9 ileo-pelvic, 10 superficial
Source: Schwartz and Dioli (1992).

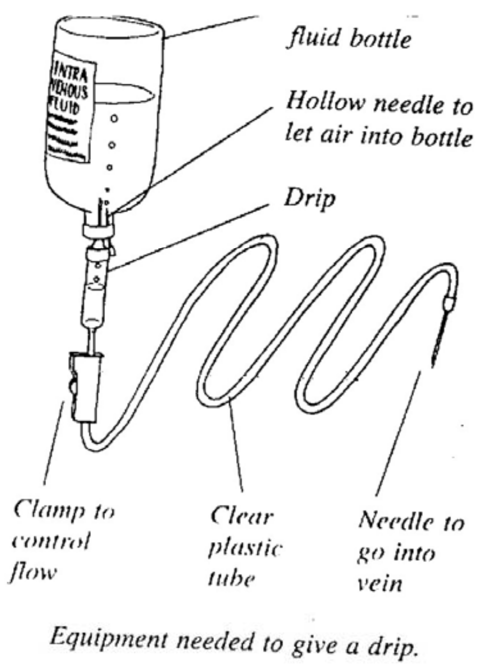

Fig32. Equipment needed to give a drip
Source: K. Rollefson *et al*. (2001).

PRODUCTION AND MANAGEMENT OF CAMELS

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PREFACE

The camel, without exaggeration, is the most ignored among the domestic ruminants in Pakistan. This is as much true in terms of lack of efforts to improve its care and productivity as it is in terms of lack of any planned research on it. Had it been an unproductive and a useless animal, its population would have gradually diminished, but it is the other way round. Its population is steadily growing. On papers, its population is being shown as stagnating, but most probably it is not so. On the international scene, there seems now a growing awakening in respect of the camel. At places, it has been termed as a 'food security animal'.

In Pakistan too, some teaching institutions have taken an initiative and have incorporated "Camel Production" in their teaching courses. No doubt, it is a very timely step.

Scientists from Germany, England, India, Australia and UAE have published books on camel. These are, of course, good books but as usual their prices are prohibitive for our students, extension workers and even for teachers. Moreover, these books contain a little information about camels in Pakistan. Therefore, an easy-to-understand book on 'Production and Management of Camels' using a question-answer format, has been compiled. This should provide ready-made answers to so many questions simmering in the minds of students, teachers, researchers and extension specialists. It embodies about 400 questions along with their answers.

The book discusses the distribution of camels in different continents/countries, breeds and types of camels with cross reference to other species, nutritional physiology and reproductive management, the way camels adapt to hot arid environment, milk and meat production and work performance, practical management and training of camels, marketing, health care and some diseases, including valuable information on several other aspects. Camel breeds and camel raising practices in Pakistan have been adequately discussed.

We feel great pleasure in acknowledging the hard work done by so many researchers/authors/editors, whose published information has been used, mostly as such, in compiling the book under reference. Their efforts have been amply acknowledged in the text/tables/figures etc. It was beyond our means to individually contact them in this regard.

We are highly thankful to Akhter Saeed MD for providing us useful literature from abroad. We are equally thankful to Dr. Ghulam Muhammad, Chairman CMS, UAF, for his cooperation in providing pertinent literature. Ch Sikander Hayat and Nawaz Ahmed Sipra also deserve our heart-felt appreciation for helping us out of many problems pertinent to the publication of this book.

No book has ever been claimed to be perfect in all respects and so is this one. The readers are requested to convey in writing their suggestions about omissions/shortcomings noticed in this book. Their suggestions would not go unnoticed.

Bakht Baidar Khan
Arshad Iqbal
August, 2003 **Muhammad Riaz**

FOREWORD

For a long time the camel has been the victim of disregard and deliberate neglect of scientists and development workers. However, the last about two decades have witnessed a resurgence of interest in this species. Most of the work to exploit the productive potential of the camel has been undertaken by those who come from such countries that do not even possess camels. I think this should be more than enough to make us realize our responsibility towards a multipurpose domestic animal species, of which this country has a sizeable population. We need to investigate its peculiarities and exploit its potential especially in terms of milk and meat production and to explore the possibility of increased export of live camels to several Middle East countries. Presently some of these countries are importing camels from Australia.

To strengthen the possibility of implementing such plans, we must be equipped with recent knowledge about various aspects of camels. In this connection and as an animal scientist myself, I feel pleasure to mention that a book with the title 'Production and Management of Camels' has been brought out by experienced teachers/researchers, which should suffice to meet the needs as mentioned above. The contents of this book make me believe that it should be as much helpful for students, teachers and research workers as for extension specialists.

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PART – III

Part – III includes:

- *Diseases*
- *Specimen Objective Questions*
- *Glossary*
- *Annexure*
- *References*
- *Subject Index*

DISEASES

Q. Give a list of diseases that commonly occur in camels.

Among others following is the list of diseases that commonly affect camels: Camel pox, contagious ecthyma, camel papillomatosis, pasteurellosis, trypanosomiasis, pneumonia, influenza, gastrointestinal disorders, sarcoptic mange, tick infestation, fly infestation, dermatomycosis, ocular problems, rabies, facial paralysis, wry neck syndrome, stiff neck, plant poisoning, saddle sores, wounds and abscesses.

Q. Discuss, in general, about the occurrence of diseases in camel.

Despite a general reputation of camel for hardiness and resistance, which largely is true for adult camels, very young camels are susceptible to several problems leading to high morbidity and mortality. Passive immunity to many diseases is not transmitted to young camels via the placenta of the dam and therefore has to be acquired after birth. Colostrum does, however, carry antibodies to diseases to which the dam has been exposed and passively transfers resistance to the same diseases to the newborn camel. Many camel owners, especially in certain East African countries, do not allow the young to suckle the colostrum, considering it bad for them. This practice certainly contributes to the high morbidity and mortality rate, which may be as much as 40% before weaning.

Death of the embryo or foetus in early gestation (reasons not yet known) and occasional outbreaks of abortion contribute further to overall mortality, poor real reproductive performance and slow herd expansion rates. Older camels usually have low death rates, 3 to 5% per year. In problonged droughts, deaths in camels do not take place until heavy losses have been suffered by other livestock. Published information on the diseases of the camel is the most plentiful of all research done on this species. This indicates that camels may be carriers of, or are susceptible to, or suffer from, a vast array of infectious and parasitic diseases.

Q. Organisms of many diseases and antibodies to several other disease organisms have been found in camels. Discuss this statement in detail.

Although organisms of many diseases have been found in the one-humped camel yet this does not mean that camels are actually susceptible to all these diseases. The presence of antibodies to foot-and-mouth disease in 70% of camels in Egypt, for example, is not associated with clinical symptoms. It is not known if the camel acts as a carrier of infection or is able to transmit foot-and-mouth disease to other species of farm animals. The presence of antibodies to other disease organisms which are of major concern in other domestic animals but about which similarly little is known in relation to camel includes Anaplasma, Brucella, Toxoplasma, Coxiella (Q-fever), bluetongue, influenza, parainfluenza, pasteurella, African horse sickness and Rift Valley fever. These antibodies are present over wide geographical areas and in varying proportions of animals (Table 30).

Table 30. Presence and prevalence of some virus antibodies in camel

Virus	Countries and prevalence*
Parainfluenza-3	Djibouti 17/53, Sudan 81/102, Oman 80/30, Nigeria (types-1,2 and 3) 43/107
Influenza	Sudan (type 1) 5/42, Nigeria types (A&B) 13/157
Bovine virus diarrhoea	Sudan 16/102, Oman 7/30
Adenovirus, respiratory syncytial virus	Nigeria 1/157
Bluetongue	Sudan 17/445, Sudan 5/102, Saudi Arabia
Rift valley fever	Kenya 22/143, Mauritania 29/41
Food-and-mouth	Egypt 69/39 (serum neutralization test), 15/39 (virus infection associated antigen test)
African horse sickness	Egypt 10-23% in imported animals
Pox viruses	Iraq, former USSR, Pakistan, India, Kenya (in 5 of 6 herds examined)
Rotavirus	Morocco 49/55
Rabies	Mauritania

* Prevalence is expressed as percentage in number of samples, thus 17/53 is 17% in 53 samples.

Source: Wilson *et al*. (1990).

Q. Describe the etiology, pathogenesis, treatment and control of camel pox.

Camel pox is one of the most important viral diseases in East Africa and parts of South Asia. It is caused by *Orthopox cameli*. Its outbreaks mostly occur during early to middle periods of the rainy season. The disease is highly contagious, from one animal to another, but scabs, contaminated tools, cloth, grazing areas and human beings also serve as fomites. Camel pox is reported most often in young and immature camels. Recovered animals show a stable and lifelong immunity, but there is no cross protection with other types of pox virus, including contagious ecthyma being clinically similar. The main clinical symptoms are characteristic skin lesions, papules appear around nostrils and lips. These papules later on take the form of vesicles, which eventually rupture. There is fever and anorexia; mandibular lymph nodes are often enlarged. Facial oedema is quite common at this stage. The localized form of pox disappears in about 3 weeks. Clinical symptoms of generalized form are more severe. Affected animals show high temperature, severe depression and anorexia. Vesicles develop all over the body. The pox scabs become covered with a thick brown crust after some time. Severe secondary infections are common. Septicaemia, reduced feed intake and resultant general weakness can precipitate death of these animals.

In dry climates the disease cures itself. In wetter areas, the disease can be severe. Mortality in calves and immature camels is very high, especially under poor management conditions, but the effects of morbidity may be equally important because they cause heavy production losses, particularly in weight gain. Some traditional owners use a vaccine made from the mild form to prevent further spread of the disease. They take scabs from animals with low levels of infection and insert them in a wound (skin scarification) they make on the animal, which is to be protected from the disease. The Lister strain of vaccinia virus applied by skin scarification has been successfully used to control a severe outbreak in Bahrain. Along with a vaccination programme, improved management strategies could diminish the prevalence of the diseases. Further education of herd owners about the etiology of camel pox, strict separation of diseased and healthy young camels, improved health care including long acting antibiotics, improved

hygiene and general supportive treatment will decrease the harmful effects of camel pox (Schwartz and Dioli, 1992).

Q. Discuss all about contagious ecthyma in camel.

Contagious ecthyma is caused by the parapox virus. Both the one-humped and two-humped camels are prone to this disease. Pox-like lesions are produced by the affected animals. Modes of transmission are similar to those described under camel pox. The virus is morphologically different from orthopox virus and can easily be identified by electron microscopy.

Clinical symptoms are similar to those caused by the orthopox virus, but a diagnosis based on these lesions can only be presumptive. The main practical differences between camel pox and ecthyma are that the latter disease is more severe and affects camels of all ages. In immature camels the lesions are mainly found around the mouth and nostrils and occasionally on the eyelids. The mandibular lymph nodes are enlarged. Due to intensive pruritus animals spend a lot of time scratching and rubbing the affected area, resulting in haemorrhages and skin excoriations. Grazing and suckling ability is impaired. Both localized and generalized skin lesions have been observed. Whether recovered animals have a lasting immunity is not clear, but according to field observations, recovered animals were not affected during new disease outbreaks. Control and care are similar to those for camel pox.

Q. Write a note on camel papillomatosis.

Simultaneous outbreaks of contagious ecthyma and papillomatosis have been reported in camel herds mainly during rainy season. Definite modes of transmission of the disease are inconclusive. Morbidity rate is quite high. Mortality in adult animals is nearly nil, but among affected calves mainly 6 to 18 months old under poor management and inclement weather, mortality rate might be high. Recovered animals were not affected during new outbreak. The zoonotic potential of the disease for human beings or other livestock is not clear.

In adult animals, the disease resembles bovine papillomatosis. Nodules are found mainly around head, neck, shoulder and udder. These become persistent and may require surgical removal. Proliferative localized or generalized skin lesions develop in immature animals. These lesions are very itchy and affected animals resort to intensive scratching and rubbing, resulting into haemorrhages. A high incidence of conjunctivitis with severe secondary bacterial infection has also been noticed. Other clinical findings include marked oedema of the head and swelling of the mandibular and

cervical lymph glands. In some cases, cauliflower like skin lesions about 0.1 to 0.5 cm evolve around nostrils and lips. Approximately 3 weeks after formation, the scabs drop off. Clinical symptoms of camel pox, contagious ecthyma and camel papillomatosis in immature animals being similar, can be easily confused. Electron microscopy has proven to be a useful tool to differentiate pox like lesions (Schwartz and Dioli, 1992).

Q. Discuss haemorrhagic septicaemia in camel in detail, including its etiology, epidemiology, pathogenesis and treatment.

Haemorrhagic septicaemia (HS) also called pasteurellosis is a disease of bacterial origin. *Pasteurella multocida* is the usual causative agent. It is prevalent in buffaloes, cattle and camel. Its outbreaks occur mainly during the rainy season and are commonly seen in low lying areas that have seasonal floods. The disease is usually seen in adult animals, but all age groups can be affected. Mortality can reach 50-80% among affected animals. Mode of infection is believed to be either by ingestion of contaminated feedstuff or by arthropods. The bacteria are not particularly resistant and do not survive longer than 24 hours on pasture.

Disease onset is acute. Clinical characteristics include high fever over 40°C, increased respiration and pulse rates and general depression. In camels, localization chiefly to subcutaneous tissue results in hot painful swellings around the neck. The mandibular lymph nodes and/or cervical lymph nodes are usually enlarged. Signs of respiratory dispnoea such as dilated nostrils or open mouth breathing and cyanotic mucous membranes are seen. In the majority of cases, haemorrhagic enteritis is present characterized by obvious clinical signs of acute abdominal pain and tarry faeces and coffee-coloured urine. Affected animals seldom recover and usually die in the next 24 to 48 hours.

On post-mortem the most obvious findings are generalized internal petechiation under the serosa of the intestines, the heart and the lymph nodes. Haemorrhagic enteritis and lesions of early pneumonia may be present. Differentiation from anthrax, blackleg and septicaemic salmonellasis is usually done by bacteriological examination. The absence of bloody discharge from the natural body orifices and a normal appearing spleen on post-mortem can help differentiate HS from anthrax.

Since HS is an acute and quite often fatal disease, early treatment is essential. Treat with antibiotics such as amoxycillin, tetracyclines or sulphonamides. Give 110 mg/kg body weight of sulphadimidine by mouth each day for up to 4 days. Recently being used more effective treatment is

the injection, popularly known as Doctor Jin. It is injected (IM) at the rate of 1ml/10 kg body weight.

Q. Is brucellosis a common problem in dromedary camels? What organanisms cause it? Suggest appropriate control measures for brucellosis.

Varying incidences of brucellosis in camel (2 to 15%) have been reported from different countries. Except three countries, the incidence of occurrence of this disease in camel is mostly between 1 and 2%. The incidence is very low in Indo-Pakistan region. Camel may be infected by *Brucella melitensis* and *Br. abortus* and possibly by *Br. suis*. The precise pathogenicity of the disease in camels is not known. The *Brucella* organisms have been isolated from camel milk, aborted foetuses and vaginal swabs. It is well recognized that there are many causes of abortion and stillbirth in the camel and this complicates the diagnosis. There is little doubt that *Brucella* infection may be a factor in infertility in the camel, but it may not be as important as it is in unvaccinated buffaloes/cattle. There is supporting evidence that where camels and cattle are closely intermingled, infection in the camels has generally been significantly less than in cattle.

Experimental infection in non-pregnant camels has resulted in only mild signs of reduced appetite, slight lameness and lacrimation. Some authorities feel that the most significant result of infection may be premature birth.

Control is best achieved in other species by the use of vaccines. Both killed and attenuated vaccines have been successfully used in camels. Many countries have eradicated the disease by reducing incidence by a few years of careful vaccination followed by test and slaughter. Brucellosis is an important zoonotic disease. In man it is a debilitating disease characterised by recurrent fever, night sweats, joint and back pains and depression. People at greatest risk are those who drink unpasteurised milk, handle raw meat and attend parturient animals. Cooked meat and treated milk is safe since the organisms are readily killed by exposure to heat in excess of 65°C (Manefield and Tinson, 1997).

Q. What do you understand by respiratory diseases complex? Discuss it in detail in relation to camel.

A combination of various diseased conditions of lower respiratory tract of camel is called respiratory diseases complex. A variety of viral, fungal, bacterial and parasitic microorganisms have been associated with outbreaks of respiratory disease problems among camels. The most common predisposing factors for respiratory diseases are sudden changes of climate,

generally poor management and lowered nutritional status. Animals under other forms of stress such as overcrowding, unsanitary conditions, draft, cold, rain and those suffering from other health problems and young stock are the classes most at risk. Mode of infection and spread depends solely on the infectious agent. Despite low morbidity and mortality rates, the recovery period of affected animals is quite long. The negative impact on overall productivity should not be underestimated due to the long recovery period. Abortion can occur in pregnant animals, particularly during mid pregnancy.

Typical clinical signs of acute onset of lower respiratory diseases are a change in respiratory rate and depth, wheezing, coughing, uni-or bilateral nasal discharge (serous, purulent or haemorrhagic), increased temperature, anorexia, reluctance to move or work, hyperlacrimation, abnormal posture such as abduction of the elbows, extended neck, head to neck angle is wider than usual, swelling above the sinus frontalis. Chronic cases of respiratory disease are characterized by weight loss and intermittent fever despite grazing. General immuno-depression makes the affected animals more prone to other infections (Table 31).

Table 31. Pathogenic agents associated with respiratory disease outbreaks in camel

Agent	Prevalence	Disease
Parainfluenza type 1:2:3	regional widespread	Pneumonia, influenza
Influenza virus A/B	Regional	Influenza
Adenovirus	Regional	Influenza
Respiratory syncytial virus	Regional	Influenza
Infectious bovine rhino-tracheitis	Regional	Influenza, pneumonia
Pasteurella multocida type A	Widespread	Bronchopneumonia
Mycobacterium bovis	Uncommon	Miliary/nodular tuberculosis
Streptococcus sp. *Corynebacterium sp. Actinomyces sp.Klebsiella*	very common	Pulmonary abscessation

pneumoniae		
Mycoplasma mycoides	regional	Pleuropneumonia
Rickettsia sp.	Widespread	Pneumonia
Trypanosoma sp.	very common	Pneumonia
Dictyocaulus vivipara filaria	Widespread	Verminous pneumonia
Echinococcus granulosus Cysticercus dromedarii	very common	Hydatid disease
Dipetalonema evansi	Regional	Pneumonia pleuritis
Fly larvae (nasal myiasis)	Widespread	Rhinitis
Leeches	regional but common	Rhinitis

Source: Modfied from Schwartz and Dioli (1992).

Typical signs of respiratory diseases of viral origin are often masked by secondary bacterial invasion. Bacteriological and histological examination should be performed if clearcut etiological diagnosis is needed. Principal treatment of affected animals includes antimicrobial therapy, improved management practices such as better housing, hygiene and good nursing care. High doses of long-acting broad spectrum antibiotics should be used in case of bacterial infections. Fistula formation between the sinus and the nasal cavity is a common sequel in most cases of sinus infection. In case of nasal airway obstruction due to purulent discharge, relief can be achieved by regular cleaning and flushing of the nasal cavity with saline solution. If treated early, prognosis is usually good (Schwartz and Dioli, 1992).

Q. Discus the prevalence of Johne's disease in camels.

Johne's disease also called paratuberculosis occurs worldwide. It is caused by *Mycobacterium paratuberculosis*. The organism is shed in the faeces and it can be ingested with contaminated feed or water. The disease is widespread in Russia. It has been reported in dromedaries in Indo-Pakistan subcontinent, Saudi Arabia, UAE and in a camel in a zoo in USA. In Russia, the infected Bactrian exhibits severe diarrhoea. Clinically affected animals are usually 2 to 3 years of age and they die within 4 to 6 weeks from the onset of clinical signs. Many are of the opinion that the disease is more severe in camel than that in cattle. In some species infection occurs at or soon after birth by the neonates contact with an infected dam. Infection in utero occurs in advanced cases in buffalo and cattle. The organism is present in milk of 10% of subclinical and 30% of clinical cases. The losses

due to this disease per annum, mainly in buffaloes/cattle, are conservatively pegged at over US$ 1 billion worldwide.

Diagnosis has been based upon the occurrence of chronic, intractable diarrhoea and the identification of acid fast bacilli in faeces and rectal biopsies. The complement fixation test appears to be reliable. CSL Ltd market a commercial ELISA test under the name of parachek which has been found very satisfactory in cattle. It is also being used in sheep and goats and should be applicable to camels. The condition shows little response to antibiotics and the infected dromedary may take up to a year to die. The genome of the bacterium *Mycobacterium paratuberculosis* has been sequenced very recently (Anonymous, 2002). The gene combinations that produce the bacteria responsible for the disease have been identified. These genes will serve as targets for the development of new generations of diagnostic tests that are critically needed for the detection and ultimate eradication of the disease.

Q. Are haemorrhagic disease and HS the two different names of the same ailment. Discuss.

These are not the two names of the same disease. However, similarity of signs sometimes may cause confusion. Certain other diseases such as haemorrhagic enteritis, salmonellosis also exhibit somewhat similar signs.

This is a serious disease of camels. Mainly racing camels in the UAE and Qatar are affected. Heavy mortalities have been reported. Major symptoms are: fever up to 41°C, animals go off feed and stop rumination, frequent dry cough, lymph nodes around neck show swelling, after a few days sickness the faeces are mixed with either fresh and red or black/tar-like blood with no signs of diarrhoea, the animal sits down and refuses to get up, death takes place after 3 to 7 days.

After death when the animal is cut open, blood can be seen at various spots such as inside the mouth, nose, windpipe, in the last stomach and kidneys, on the sac around the heart and on the guts.

This disease is also known as haemorrhagic diathesis (HD), *Bacillus cereus* intoxication. It is caused by a bacterium called *Bacillus cereus*. This may be carried on feed contaminated by cattle dung. If a camel is fed with grain and other concentrates but not enough roughage, the contents of the ruman (the first stomach) become very acid. The acidic conditions also help the bacteria multiply quickly and produce harmful toxins. To avoid creation of favourable conditions for multiplication of bacteria, feed plenty of

roughage in the feed. Do not store freshly cut feed in bundles since heat is generated which favours multiplication of bacteria.

Since the disease takes a very rapid course, therefore treatment usually fails. However, if HD is suspected, treat the animal quickly. Dissolve 500 g of sodium bicarbonate in water and drench the camel twice a day for at least 2 days. This reduces acidity in the rumen. Inject antibiotics and antipyretic (Tomanol) drugs. Give a drip with electrolytes, glucose and vitamins.

Q. What type of disease is salmonellosis? At what age camels are usually affected? Give salient symptoms, cause and treatment of this disease.

It is a bacterial infection caused by bacteria of the genus *Salmonella*. It is passed on by an animal eating feed or drinking water contaminated with faeces from infected animals. Calves over 2 weeks of age are the usual victims. It starts as gastroenteritis with diarrhoea and can develop into blood poisoning or septicaemia. It often results in death. In suckling calves up to 20% deaths have been reported. Animals that recover often have the bacteria in their faeces for a long time, thus become a source of infection for other animals. This disease is equally dangerous for other animal species and people, especially small children, old people and those with poor immunity. Therefore infected animals should be handled with great care. Proper diagnosis is only possible by culturing the bacteria in a laboratory.

Salient symptoms are: yellowish or greenish-grey, foul-smelling diarrhoea, faeces often contain blood, fever, dehydration, sunken eyeballs, dry mucous membranes. More often the animal dies 1 to 2 weeks after the disease symptoms appear, but in very acute cases may die within 24 to 48 hours. In septicaemic cases, body temperature rises rapidly, the animal becomes dull, rests and does not get up, shows difficulty in breathing, uncoordinated movements, lungs and joints may become inflamed (K. Rollefson *et al*., 2001).

To treat the infected animals, give oxytetracycline antibiotic by mouth as well as through injection. Inject enrofloxacin (e.g. Baytril) 5 mg/kg body weight. Treat with oral rehydration fluid. Give a drip of 5 litres or more of lactated Ringer's solution mixed with sodium bicarbonate. However, if the animal is not treated within 24 to 48 hours, it is likely to die. Moreover, once the septicaemic form has developed, treatment is often not successful, especially if lungs are also involved.

Since prevention is better than cure, therefore, vaccinate breeding females during pregnancy so that the antibodies are transferred to the newborn calves. Make sure that calves get as much colostrum as possible and as early as possible after birth. Separate sick animals from healthy ones. New animals entering the herd should be kept separate for about a month. Keep drinking water and troughs clean and free of contamination by faeces. People treating sick calves should not handle healthy calves at the same time.

Q. Give the local names of Anthrax. Discuss all about this disease.

There are several local names of Anthrax. Some of these are sut, sujhan, mohri etc. It is a highly infectious disease. The sick animal meets a fatal end. *Bacillus anthracis*, which is extremely resistant to high temperatures and drought, is the causal agent. The disease is transmitted through grazing close to the ground and by inhaling dust. Biting flies (tabanids) and nasal bot flies are also the probable sources of transmitting this disease. Watering points, livestock markets and other places where animals are crowded, predispose them to anthrax.

The usual signs are: high temperature, rapid death with no signs of illness before hand, blood coming out of mouth, nose, anus (blood dark red and does not clot), most often best animals in the herd are affected, diarrhoea and pain in the abdomen, bloat, painful swellings on the throat and neck, fast irregular pulse, the spleen enlarged 3 to 5 times.

Treatment requires immediate injection of penicillin 10,000 units/kg body weight and streptomycin 8 mg/kg body weight into the muscle twice a day.

It must be remembered that anthrax is a highly infectious disease that can kill people. Be careful when handling animals that are sick with anthrax. Do not touch them or their blood. Wear plastic bags on your hands in case you must touch them. Vaccinate camels with Blanthrax or anthrax vaccine. Avoid grazing where anthrax has previously occurred. Do not open the carcass. Avoid touching a carcass of an animal died of anthrax. To stop the disease from spreading, destroy the carcass by burning rather than burying it. Make sure it burns completely (K. Rollefson *et al*., 2001).

Q. Write a note on prevention and treatment of tetanus in camels.

Tetanus is rare in camels, mostly humans and horses are affected. Clean deep wounds promptly with potassium permanganate or hydrogen peroxide. Put the animal in a quiet, dark place or plug its ears and put patches on its eyes. Inject 3000 units tetanus antitoxin under the skin. Inject penicillin for at least 7 days. Inject propionylpromazine (Combelen). To

calm the animal, inject a muscle relaxant such as Methocarbamol (Robaxin). Locate the infected wound, open it to expose it to the air, drain out the fluid and dress it with an antiseptic such as potassium permanganate. If the animal cannot eat, feed with milk, oatmeal gruel and linseed gruel by working it into mouth from the side.

Q. What type of disease is skin necrosis of camel? Discuss briefly its various aspects.

Skin necrosis is an infectious disease. A variety of infectious agents have been isolated from necrotic skin lesions, including *actinomyces cameli*, *streptococcus sp*., *staphylococcus aureus* and *corynebacterium sp*. Dietary salt deficiency has been associated with outbreaks of this disease. Spread of the disease occurs through close physical contact such as crowding at water sites and night enclosures as well as through contaminated fences and trees where affected animals resort to rubbing and scratching. Immature animals are affected more than adults. Mortality is usually low.

A single, flat ulcerative lesion is characteristic of the disease but multiple lesions may be seen occasionally. The head, neck and shoulder region are the commonly affected sites. Painful swellings of small skin areas mark the beginning of the disease. Skin necrosis starts in the center and spreads outward, followed by sloughing of necrotic tissue. Circular ulcers of varying diameter (2 to 10 cm) are clearly demarcated from surrounding healthy skin. Secondary bacterial infection results in purulent discharge. The draining lymph nodes are enlarged and painful. Healing takes 3 to 4 weeks and scar formation is common. Risk of septicaemia is high when lesions develop on top of regional lymph glands.

Septicaemic animals should immediately be administered broad-spectrum antibiotics and provide good nursing care. Treatment of lesions consists of good debridement (removal of foreign material and contaminated tissue), flushing with iodine and topical dressing with anti-bacterial and insecticide preparations. Regular supplemental feeding of salt may reduce the incidence of skin necrosis.

Q. What type of disease is rabies? Discuss its etiology, clinical findings along with treatment/control.

Rabies is an important zoonotic viral disease. It is widespread throughout Africa and most of the Asian countries. All animals apart from reptiles and birds are susceptible to the disease. Important carriers are domestic and stray canines and wild carnivores such as jackals and wild dogs. It is mainly transmitted by bite wounds. Incubation period ranges from one month to

several months. Rabies is considered a fatal disease, however, recovery has been reported.

When an animal is bitten by a rabid dog, infectious saliva enters its body tissues, the virus replicates, then travels to the brain and from there to the salivary glands. Typical behavioural changes in rabid animals are often accompanied by progressive paralysis. Common behavioural changes are viciousness, increased activity or excitation and pica (compulsive eating of non-nutritive substances). Dumb and furious are the two forms of rabies observed in camels as well as other animals. The furious form of rabies is common. Rabid camels show profuse salivation due to paralysis of the throat, the animal being unable to swallow. There is aimless running off from and to the herd and increased aggressiveness. It must, however, be kept in mind that behavioural changes do occur in animals affected with brain diseases. Normal ingestion, locomotion, rest and sleep behaviour can be modified exhibiting an increase or decrease. Marked changes in social behaviour towards man and other animals are also seen. Increased aggressiveness and activity in camels have also been noted in case of coenurosis, a bacterial meningitis caused by *Listeria sp*. and nasal bot.

Since rabies presents a high zoonotic risk for human beings, animals with rabies-like symptoms should be immediately isolated and killed if evaluation of their history is suggestive of rabies, such as previously attacked by wild carnivores or stray dogs. Controlling rabies in endemic areas is only possible through mass vaccination of stray dogs and immediate elimination of suspected rabid animals. It is strongly recommended that all persons who frequently handle domestic or wildlife should receive a pre-exposure immunization. Titres should be checked every year.

Q. Discuss the frequency of occurrence, etiology and control of toxoplasmosis in camel.

On serological evidence, the camel has been found to have quite high incidence of *Toxoplasma gondii* infection in widespread locations; Afghanistan 73%, Egypt 3 to 6%, Indo-Pakistan subcontinent 11 to 13%, Somalia 16%, Sudan 23% and Turkmenia 28 to 73%. In one camel showing dyspnoea and pyothorax (pus in pleural cavity) 24 litres of turbid fluid were drained from pleural cavity. *Toxoplasma tachyzoites* were found in macrophages (any form of mononuclear phagocytes) in smears. The fluid had a titre of 1:20000 for *T. gondii*. There is a possibility that infection may be a factor in infertility and/or occurrence of abortion. Because of *T. gondii*

infection, the camel must be regarded as a significant public health risk to closely associated humans. Infections may range from slight fever, sore throat, lymphadenopathy, splenomegaly, joint soreness to abortion, stillbirth or neonatal death when human females are infected.

Diagnosis is based upon a variety of serological tests (complement fixation, flourescent antibody and ELISA) and demonstration of the organism in affected tissues. Focal necrosis is the typical lesion.

It is a common cause of sporadic abortion and infertility in sheep. Control can be effected by deliberately exposing young sheep to infection sufficiently in advance of their first pregnancy for immunity to develop. The known hosts of the parasite are the domestic cat, mountain lion, leopard cat and bobcat. In these animals, oocysts are formed and passed in faeces. Infection initiates in non immune animals that ingest them. Ingestion of oocysts results in sporulation and release of sporozoites that pass to extra intestinal tissues. Carnivores are infected by ingestion of cysts present in infected flesh. The parasite is intracellular. Treatment is based upon combination of sulphonamides and pyrimethamine, but may not be possible on a herd basis in large animal species. Control is based upon hygiene and adequate cooking of meat. Cat litter and faeces should be disposed of in a safe manner and gloves worn during the process (Manefield and Tinson, 1997).

Q. Discuss the occurrence of mastitis in camel, indicating the causative organisms, symptoms and treatment.

Mastitis appears to occur less frequently in the camel than in other domestic milch stock. It is interesting since domestic milking camels are often fitted with udder covers to prevent suckling, which become contaminated with milk and are rarely washed. Despite its contamination, probably the cover reduces incidence by providing protection against trauma and gross contamination. It is possible that twin duct anatomy of the camel teat in some way protects against mastitis. The fact that camels are mainly found in dry arid climate, which generally helps in the reduction of contamination.

Peracute gangrenous mastitis does occur, but rarely. It usually just results in the sloughing of the affected mammary unit(s). Adequate antibiotic treatment should be provided for about 7 days. It has been associated with *Klebsiella pneumoniae* and *Escherichia coli* infection. In milder cases swelling, heat and pain of the infected mammary unit may be seen, while in some signs may be restricted to changes in the milk in the form of faint

discolouration with blood and may be some flocculated material present. *Staphylococcus aureus*, *Streptococcus sp*. and *Pasteurella haemolytica* are the most common primary pathogens, while *E. coli*, *Pseudomonas sp.*, *Miorococcus* and *Klebsiella* are believed to be secondary infections. Abscess formation in the inguinal lymph nodes (mammary nodes) occurs occasionally but causes considerable discomfort. Usual treatment is local poulticing with phlegmon ointment for about 5 days. Surgical drainage is sometimes required to relieve pain.

Subclinical mastitis is probably more common. There is reasonably a good correlation between somatic cell count (SCC), California mastitis test and the presence of subclinical infection. Subclinical cases had 7.4 to 12 X 10^6/ml milk. Surf field mastitis test developed by Muhammad *et al*. (1995) has shown good response in detecting subclinical mastitis. It is very cheap too.

Treatment is best based on culture and sensitivity and the use of an appropriate antibiotic infused into the infected quarter(s) and administered parenterally. The infusion of bovine antibiotic mastitis ointment is complicated in the camel because each teat has two relatively fine ducts, which do not allow insertion of ointment tube nozzles without discomfort. Since the ducts originate from separate cisterna, therefore both ducts of any infected quarter should be infused with ointment. Really difficult animals may have to be tranquillised and rolled on their sides with the hind legs roped back. Before udder infusion, oxytoxin, 5 ml IM, is administered to induce ‘let-down’ and allow a more complete emptying of the udder. The teat should be cleaned with alcohol and disinfected with pyodine prior to infusing ointment. Commonly used infusions are Mastalone once daily, Ampiclox 12 hourly and Orbenin LA one tube three times at 48 hour intervals. Time of withholding the milk from human consumption subsequent to the final treatment, as indicated by the manufactures should be strictly observed. Full doses of a compatible antibiotic are injected parenterally to maintain blood levels for a period of 5 days. Baytril (enrofloxacin) has been found to enter milk very quickly after injection (Manefield and Tinson, 1997).

Q. Name important zoonotic diseases with reference to camel production and give very brief account of some of them.

Anthrax: It is a bacterial disease and can cause considerable losses in camel in affected areas. It can be confused with black leg (blackquarter caused by *Clostridium chauvoei*), but anthrax does not cause skin

crepitation (crackling sound). Death is sudden in peracute cases. The organism invades man by inhalation, ingestion or skin contact. It is highly fatal in man unless treated promptly.

Brucellosis: Both *Brucella melitensis* and *B. abortus* and probably *B. suis* can infect camel. However, abortion and premature birth has many causes in camel. The organism has been isolated from camel milk, aborted foetuses and vaginal discharge. Man can be infected by ingestion, handling infected material and conjuctival contact. The infection in man is severely debilitating to fatal.

Echinococcosis (Hydatidosis): The camel is an important intermediate host in this disease. The incidence is high wherever camels are found. Cysts occur in both liver and lungs but camel is intermediate host only. It is a slowly developing but potentially fatal disease in man resulting from cyst formation in liver, lung, and often in brain. In some countries human infection rate is up to 4%. Dogs and other canids should be prevented from eating raw organs, especially those containing cysts.

Influenza: There is plenty of evidence of various mammalian species including camel being naturally infected with influenza virus. A strain of virus that caused illness in both the local Bactrian camels and human population has been isolated in Mongolia.

Leptospirosis: The incidence in camels has been reported only from Egypt. *L. icterohaemorrhagica* has been shown to cause haematuria and abortion. The disease is usually mild in man with influenza like symptoms lasting about 10 days; in rare cases meningitis has been reported. Infection is by contact with skin or conjuctiva. Milk, urine as well as wet soil may be sources of infection.

Plague: Camels can intensify plague caused by *Yersinia pestis*, classically carried by rodents and transmitted by fleas, by interaction with the rodent population. In man the disease has an acute highly fatal septicaemic form, and a less acute form shown by lymph node enlargement. The handling or ingestion of camel products can be dangerous. The bacterium can survive up to 5 days in milk, 23 in pelts and 165 days in sputum and exudates.

Q Fever: Q Fever is a rickettsial disease and ticks can be involved in transmission. The organism (*Coxiella burnetti*) causes no noticeable disease in camels, but serology has been positive in up to 39% camels in some regions. Humans may be infected by inhalation of dung contaminated dust and ingestion of, or contact with contaminated camel products. Symptoms

in man are similar to severe influenza, fever and secondary pneumonia lasting 5 to 15 days.

Rabies: It is spread mainly by bites of infected animals. The virus present in their saliva is inoculated in the bite trauma. Foxes are the main reservoir of the disease. Camels can be infected by dog or fox bites, but the chances of spread from camel to man appear to be small. Nevertheless, camel bites in endemic (prevalent in a population or geographical areas at all times) areas should be regarded potentially dangerous, especially if the animal is showing signs of unusual behaviour at the time of bite or does so within next 7 to 10 days (signs such as unusual aggression, chewing inanimate objectives with salivation or self mutilation.

Rift Valley Fever (RVF): RVF is a serious, sometimes fatal, viral disease of man and ruminants. Transmission is by insects including mosquitoes of the genera *Culex*, *Anopheles* and *Aedes* and *Culicides sp*. Mainly it occures in African countries of Egypt, Nigeria and Sudan. In camels the only reported sign of the disease has been an increase in abortion rate during epizootics of RVF usually associated with increased seasonal rainfall. Man can be infected by handling infected carcasses. The symptoms are malaise, headache, chill and fever, while fatal haemorrhagic forms have also been reported.

Dermatophytosis (Ringworm): It is a skin disease in camels under 3 years of age with a peak incidence between age 3 to 12 months. Small, round alopecic areas appear on different parts of camel’s body. Handlers may become infected and exhibit typical ringworm lesions on their skin. Secondary bacterial invasion causes inflammation and suppuration.

Salmonellosis: It is suspected as being a common zoonotic bacterial disease. Sometimes serious outbreaks have been reported in the camel characterised by foul smelling blackish-green diarrhoea. Chronic cases exhibit intermittent diarrhoea and gradual wasting. Abortion is common, also death may occur. Man becomes infected from contaminated surroundings or animal products. The disease takes the form of diarrhoea, abdominal pain and vomiting. Adults mostly recover but the disease is very dangerous to children.

Sarcoptic Mange: The mite *Sarcoptes scabei cameli* causes this important disease leading to debility and disrupted productivity. Man can be infected from close contact such as riding an infected camel. Infected humans suffer intense hand and body irritation.

Toxoplasmosis: Infection with the parasite *Toxoplasma gondii* can cause abortion and/or infertility in the camel. Humans can be infected by handling raw products or consuming inadequately cooked meat leading to mild fever, lymphadenopathy or to serious sporadic cerebral involvement. Abortion and stillbirths have also been reported.

Tuberculosis: This bacterial disease is rare in camels. An occasional incidence in a herd, however, may reach a level of 9 to 10%, resulting into slow wasting to emaciation, with coughing and respiratory distress. Transmission to man is via milk, saliva or water contaminated by affected animals. Evidence of the disease is similar to that in animals.

Q. Describe etiology, clinical findings, pathogenesis, treatment and control of trypanosomiasis in camel.

Trypanosomiasis, usually caused in camels by the protozoan *Trypanosoma evansi*, is a major clinical disease and cause of economic loss. Unlike other trypanosome species, *T. evansi* does not have to undergo part of its life cycle in tsetse flies and it is transmitted mechanically by other biting flies. These flies are usually of the tabanid group, mainly of the genus *Tabanus*, but some so called stable flies of the genus *Stomoxys*, also transmit the disease. In some of East African countries, the major tabanid vectors are *Philoliche zonata* and *P. magretti*.

Trypanosomiasis is most prevalent in the rainy periods of the year. Herders usually keep animals away from tsetse-infected areas and other known centers of infection but when systems are forced to become sedentary, the risk of infection increases. Riverine areas, large irrigation channels and watering points are always major danger areas, which cannot be avoided completely. All age groups are susceptible and repeat infections are common. Animals under any form of stress, including lactating females, are especially vulnerable to infection. Because of the suppressive effects on the immune system, infected animals also become susceptible to other diseases. Having been present in the blood and lymphatic system, trypanosomes can penetrate the central nervous system and joints and thus may become less accessible to treatment and to clinical diagnosis by demonstration of the protozoan in the peripheral blood stream. The trypanosomes are present in the blood when the camel has fever.

Many older tests for detecting trypanosomiasis, including mercuric chloride, are still used for *T. evansi*. Modern, rapid and effective techniques are increasingly being employed, including complement fixation and card agglutination tests as well as enzyme-immunoassay (ELISA) and radio-

immunoassay (RIA). These are much more effective in detecting the disease than the older ones. Research has shown immuno-assay to be at least six times more sensitive than haematocrit centrifugation and it is recommended that ELISA should be used in the routine diagnosis of infection. New techniques are being developed rapidly and even ELISA may no longer be the most useful diagnostic tool in near future.

Another method for the detection of live trypanosomes in blood is by the use of ion exchange columns. The ion exchange gel is packed into plastic syringe bodies and the trypanosomes are collected in sealed Pasteur pipettes. After centrifugation, the pipette tip while immersed in a very shallow water bath, is examined with a 20 X objective. Trypanosomes may be seen undulating in the fluid within the pipette tip. The method is claimed 98% accurate, but requires more apparatus, preparation and skill development time. More recently a latex agglutination antigen test has been developed and is marketed as ‘Suratex’. It comes with all necessary equipment and reagents and can be completed in the field in about 20 minutes. The test has been declared a diagnostic breakthrough by the manufacturer.

The major symptom of the acute form of the disease is severe anaemia. However, in camels the disease due to *T. evansi* is usually chronic. This is typically shown in slow weight loss, intermittent high fever, general muscular weakness, especially in hind quarters, pale mucous membranes and collection of fluid, especially in the abdominal region. Packed cell volumes of blood plasma are usually 18-20% in infected animals compared to an average of 30% (range 24-42%) in healthy ones. In more severe cases, late term abortions and premature births of calves are very common in pregnant animals, resulting also in loss of milk production.

Health care and hygiene programmes can help in control. Watering at night or at midday reduces the risk of being bitten by flies. Preventive measures before the onset of the disease (Chemoprophylaxis) and curative measures after the disease is clinically evident (Chemotherapy) have shown varying success in controlling and combating the disease (Table 32). As for all trypanosome diseases, drug resistance due to misuse and especially by using too small doses or diluting the drug with water or some other liquid is an increasing problem. In addition, some drugs that are effective in other domestic livestock are poorly tolerated by camels. Newer drugs, particularly a new arsenic-based compound and pour-on repellents are helpful in controlling/preventing the disease. Many new drugs are easy to

handle, can be administered by a variety of routes, have wide tolerances, are long acting and may be released into the metabolism over a long period of time for even greater effect.

Until eradication becomes feasible, regular monitoring is necessary to prevent large scale death losses in areas having acute outbreaks and diminished production and athletic performance with the chronic form. The efficiency of monitoring will be greatly assisted by the availability of the ELISA and PCR tests. Simple monitoring on the basis of frequent (1 to 2 weeks apart) estimation has proved useful in areas with high death risk. All camels with a PCV <25% were treated.

Table 32. Drugs and their dosage for treating camel trypanosomiasis

Drug		Dosage and route	Effect	Remarks
Chemical name	**Trade name**			
Isometamidium chloride	Samorin	50-100mg/100 kg body weight IV	Curative	Severe local reaction by IM route
Cymelarsen		0.25 mg/kg	Curative –90 days	Deep IM injection
Suramin	Naganol, Antrypol	12 mg/kg body weight IV	Curative (not *T.congolense*), prophylactic 3 weeks	Paravenous injection causes severe reaction & absceses
Quinapyramine methylsulphate	Trypacide sulphate Antrycide sulphate Noroquin	3-5 mg/kg body weight, subcut	Curative (*T.congolense* & evansi)	Local tissue reactions common
Quinapyramine chloride methyl sulphate	Trypacide prosalt	5-8 mg/kg body weight subcut	Curative prophylactic (4-6 months)	Local tissue reactions common

Source: Wilson (1998).

Q. Discuss the cause, symptoms and treatment of Dipetalonemiasis.

It is caused by a parasitic worm (*Dipetalonema evansi*), which lives in the spermatic cord, blood vessels in the lung, the heart, the lymph nodes and the mesentery. The worm larvae live in the blood. The disease is carried by Aedes mosquitoes. Whether the disease can be carried by other biting insects such as ticks or flies is not precisely known.

It is a serious problem in Pakistan and has also been reported from some other areas. It reduces the condition of the affected animals leading to shrunken hump, difficulty in breathing and enlarged testicles. The disease

has a long course and renders the camel unable to work. The worm larvae can be seen through a microscope in a wet blood film, moving around like a snake. The larvae measure 250 to 290 µm long and 6 to 7 µm wide . This disease can be confused with trypanosomiasis and conditions arising from other internal parasites and poor nutrition. Prevention may be effected by controlling biting insects. Sick animals should be treated with Ivermectin injection (0.2 mg/kg body weight) subcut. Repeat it after 3 weeks (K. Rollefson *et al*., 2001).

Q. Are camels prone to parasitic diseases?

Yes, a wide range of parasitic diseases are found in camels, including internal and external parasites. Although mortality directly due to parasitic diseases is very low yet economic loss because of parasite infestation is undoubtedly important.

Q. Name the important internal parasites found in camel. Also mention their sites and disorders caused by them.

Helminths (roundworms) and cestodes (tapeworms) of the gastrointestinal tract are the most common internal parasites. Some e.g. *Haemonchus contortus*, are common in many animals, while others including *H. longistipes*, *Camelostrongylus mentulatus* and *Globidium cameli*, are virtually restricted to camels. *Trichuris, Impalaia, Trichostrongylus,* Cooperia and *Oesophagastomum* are some other important round worms of camels.

The major clinical symptom of parasitic gastroenteritis is severe diarrhoea. Diarrhoea may result from other causes such as sharp changes in diet, especially at the beginning of the rains. Parasitic gastroenteritis may, however, be linked to the rains through an upsurge in parasite burden at this time. In acute cases of diarrhoea, there is severe loss of body fluid and minerals resulting into rapid loss of body weight and condition. Parasitic diarrhoea can usually be cured by broad-spectrum anthelmintics used strategically. If bacterial or viral infection is also suspected, long-acting broad-spectrum antibiotics and sulpha drugs reduce the severity of the problem along with oral replacent of body fluids and supplemental feeding. Close attention should be given to management including cleanliness of watering points, rotational grazing and frequent changing of night enclosures or bedding grounds.

The Arabian camel is a principal intermediate host of hydatidosis, which is also commonly referred to as echinococcosis. This disease is a major zoonotic (animal disease transmissible to man under natural conditions)

problem in many camel-rearing areas. Cysts of *Echinococcus granulosus* are found in camels over a very wide area (Table 33). Prevalence rates are usually higher in camels than in other domestic animals, as is the proportion of viable cysts. Most cysts are in liver but the lungs are also seriously affected. In nomadic lifestyle, failure to dispose of hygienically the human faeces and living in close association with dogs is probably a major etiological factor in man-dog-camel cycle of this disease.

Table 33. Distribution and prevalence of hydatidosis in camels

Country	Animals examined	Infection level (%)	Remarks
Egypt	155	31.6	Mainly in lungs (70.8% infection with complement fixation test
	204	8.3	0.2% infection in cattle, 0.4% in sheep
Ethiopia	78	5.1	
India	40	50.0	All in older camels, 14.7% fertile
Iraq	152	20.4	Mostly in lungs, 51.6% fertile
Libya	204	16.7	59% in adults, 5% in young, 58% in lungs, 40% in liver
Morocco	n.a	80.0	
Nigeria	3598	55.5	Lungs, liver and spleen, 38% fertile
Saudi Arabia	612	4.7	Mainly in lungs, 38% fertile
Somalia	958	14.8	
	300	6.0	
Sudan	51	35.3	83% in lungs, 46% in liver and 17% cysts in liver fertile
	141	45.4	Lung involved in 91% cases

n.a. = not available.
Source: Wilson *et al*. (1990).

Bacterial and other microbial parasitism of the gastrointestinal tract is also widespread. Coccidiosis (due to *Eimeria sp.*, usually *E. cameli* and *E. dromedarrii*) is a major debilitating disease of young stock. Other common pathogens such as *Salmonella sp*., *Eimeria coli* (causes coccidiosis), *Clostridium perfringens* and *Mycobacterium paratuberculosis* also cause severe morbidity. *M. paratuberculosis* causes Johne's disease leading to very severe diarrhoea and wasting (Wilson, 1998).

External Parasites

Q. Give a detailed account of sarcoptic mange in camels.

Sarcoptic mange is one of the important diseases of camel. It is caused by *Sarcoptic scabiei cameli* (a minute burrowing mite). It is a widespread and contagious disease. It is transmitted through close physical contact at watering holes, dust bath areas and housing enclosures. Contaminated

objects such as grooming tools, blankets and saddles also act as fomites (agents of transmission of an infection). Young, immature, stressed adults and debilited animals are generally affected and usually develop into the chronic generalized form of mange. Healthy animals if affected, have localized lesions. Poor management and inclement weather can increase morbidity and mortality rates.

Eggs deposited by female mites in the horny outer layer of the skin undergo three development stages (larvae, nymphs and adults) in about 17 to 21 days. The adult mites mechanically damage the skin of the host by making minute burrows. Allergic reaction is shown to mite saliva and faeces usually followed by secondary infection. Intense pruritis evolving small vesicles and inflammatory reaction of the skin characterize the beginning of the disease. Pruritis is severe and affected animals resort to extensive rubbing and scratching. Affected areas show loss of hair and become moist and suppurative. Fully developed mange is characterized by scab formation and thickening of skin. Most affected areas are the head, axillary, inguinal and perineal areas. Chronic cases of mange show grey coloured and folded hyperkeratotic skin. Affected animals show a general loss in condition, decrease in milk production and poor reproductive performance.

Successful treatment requires improvement in management practices and overall sanitation. Overcrowding, mingling of affected animals with healthy and contact with contaminated tools should be avoided. It is recommended that whenever possible, affected animals should be treated and handled by only one person, who is not involved with handling unaffected animals, because herders can also serve as fomites. Topical application of acaricides present an effective, but labour intensive treatment. Vigorous brushing of affected areas with dip solutions is necessary. The treatment may be repeated each ten days until healing is complete.

Systemic treatment with ivermectin, subcutaneously injectable antiparasitic drug, has shown good results in controlling and treating camel mange. The recommended dosage for cattle 1ml/50 kg body weight is effective in camels. Occasionally local tissue reactions such as swelling or abscessation can be observed. Despite efficacy of ivermectin, its clinical response takes time and treated camels can still be a source of infection until clinical response has fully taken place. In addition, spraying with an acaricide to kill mites on the skin is advisable.

Q. Describe the etiology, symptoms and treatment for camel dermatomycosis.

Dermatomycosis also known as ringworm is the skin condition resulting from infections by one or several fungi. These usually include the three genera namely *Trichophyton*, *Microsporum* and *Epidermaphyton*. The first is the most common organism in camels. High humidity, overcrowding and nutritional deficiency (vitamin A?) are conducive to the disease. As many as 80% of calves show symptoms in affected herds but spread is slow and mortality directly from dermatomycosis is rare. There are two clinical types of ringworm. The first shows typical 'ringworm' lesions that are grey-white in colour, circumscribed 1 to 2 cm in diameter, slightly raised hairless patches. The second is a more generalized infection and in this case the problem may initially be confused with mange. Infections in older animals are rare, presumably immunity develops after an attack. Diagnosis can be made tentatively on symptoms but should be confirmed microscopically. For direct microscopic examination, samples are placed on a glass slide, then covered with 20% potassium hydroxide or sodium hydroxide, shortly heated up and then examined for presence of fungal mycelia and spores. Scrapings for examination should be obtained from the edge of the rings as the aerobic fungi cannot survive under the crusty lesions.

A variety of medications for treating ringworm in other livestock are available (Table 34). Lesions should be scrubbed clean with soapy water first and all scabs and lesions removed must be burnt as they are likely still to be infective. Whole body treatment using sprays and washes is recommended when an entire herd is affected. Where secondary infections of bacteria are evident, an antibiotic treatment should be added to the curative regime.

Table 34. Common medications used to treat dermatomycosis in other livestock species

Dispension/drug name	Directions
Ointments	
Whitfields ointment	
2-4 % thiabendazole ointment	two to four times/day every 5 days
Propionic ointment	
Solutions	
Lugol's iodine solution	once every 2nd day
1:200-1:1000 quaternary ammonium compounds	once every 2nd day
Hexetidine	once a day

0.01% - 0.1% natamycin	twice every 4th day
Sprays/washes	
Agricultural Bordeaux mixture	once daily for 5 days then weekly
0.5% lime sulphur	
0.5% sodium hypochlorite	
1:300 Captan	
0.5% chlorhexidine	
Systemic	
10% sodium iodide 1g/14 kg body weight	intravenous (once), repeat after one weak

Source: Schwartz and Dioli (1992).

Q. Ticks commonly found on camels belong to which family? In what way ticks harm camels?

Ticks commonly found on camels belong to the family *ixodidae*, the so called true ticks. Female ticks deposit their eggs in sheltered spots. The newly hatched larvae also called seed ticks wait on vegetation till they are attached to a suitable host where they feed themselves on blood and or lymph of the host till they are fully engorged. They detach after having engorged. Each development stage (larvae, nymph and imago) of the tick requires a new host after feeding. Inclement weather has a negative effect on hatching and moulting time. After rainy season there is a marked seasonal decrease in tick burdens on camels. Average tick burden in dromedaries kept under pastoralists and nomadic conditions is about 50 to 100 ticks per animal during the dry season.

Physical irritation and wounds caused by ticks may allow entry of other disease organisms and blood loss from heavy infestations can cause anaemia, especially in young calves. An adult female tick can remove 2 ml blood. Adult ticks are usually seen around anus and genitalia but nymphs often hide in the longer hair along the back, hump and neck. Heavily infested animals show anaemia, general loss of productivity and body weight.

A thorough examination is necessary to diagnose tick infestation. Heavily infested animals should be treated with pour-on acaricides or sprayed. In adult animals, regular application of tick grease to common sites is recommended. Immature animals especially suckling calves should be regularly treated in the first few months with pour-on acaricide to reduce preweaning mortality due to heavy nymph infestation. Avoiding heavily

tick infested grazing areas, overcrowding at watering sites and holding enclosures will also help to control tick infestation.

Q. Discuss tick infestation of camels in detail.

Tick infestation of camels is a universal problem. All age groups are prone to it. It can be particularly troublesome where high-density husbandry is involved such as resting camps of racing and breeding camels. Most of such ticks are members of Ixodidae family, commonly known as hard ticks. Infesting ticks vary from region to region e.g. *Hyalomma dromedarii* is the most common on the Arabian peninsula with *H. anatolicum excavatum* also being common there and in North Africa. *Dermacentor sp*. are commonly found in Asian region. In Australia, *Boophilus microplus*, the common cattle tick, also infests camels but cattle are its preferred host. *Amblyomma sp*. are found on camels in Africa and Arabia. *Rhipicephalus sp.* occur in Ethiopia and Kenya. In Australian East Coast regions, where *Ixodes holocyclus* is found, clinical cases of paralysis may be seen in young camels recently introduced to the environment.

The life cycle of ticks may vary from two to three hosts depending upon the environmental conditions and host availability. Clinical signs vary and depend upon the age of the host animal and the degree of infestation. In young animals very heavy infestation with larval and nymphal stages (thousands of ticks) may cause marked debility, anaemia and death. Camels aged 2 to 3 weeks have been observed to die due to thousands of larval and nymphal ticks attached. These are not obvious unless the examiner runs his fingers through its coat. The legs of camels introduced into rested camel yards may be literally attacked by large numbers of adult ticks. The camels thus attacked are found running around within the yard stamping and shaking in distress due to irritation. Ticks most commonly attach to perineal, inguinal and axillary regions but generalized attachment masked by winter coat, can lead to irritation which results in some hair being lost from rubbing and bitting.

Most commonly the results of tick infestation manifest as secondary problems. This may be focal of bacterial abscessation at the points of attachment, especially under the tail and on the perineum. Myiasis may result at these sites of abscessation or, especially in screw worm areas, as a result of bleeding from attachment sites. Corneal ulceration can result from attachment of a tick to the eyelid margin. The cornea may be scratched due to the head being used to rub an irritable leg area with tick attached.

Camel ticks may be involved in the epidemiology and spread of many diseases. Some of these are of no clinical significance in the host animals but of considerable importance to other livestock and dangerous to man. Among these are *Yersinia pestis* infection (plague), Crimean Congo Haemorrhagic Fever (CCHF) a deadly zoonosis, dermatophilosis, FMD, rinderpest etc. Full significance of the tick/camel role as a vector/reservoir for many diseases is not known as yet. It is, however, advisable in the interest of animal hygiene, to minimize tick infestation in camels whenever possible.

The old method to pluck the ticks off the animal body does not work and is highly risky. Most commonly available acaricides are effective for tick control but overuse of understrength solutions appears to have led to tick resistance developing in some areas. Barricade 5® gives good continuing protection if repeated every 4 to 6 weeks. Nucidol® and Malathion® and Amitraz are effective as long as resistant strains are not involved. The larval stages of many ticks are highly resistant to chemical treatment. It has recently been shown that intensively stocked areas such as housing yards and dry lots can be subjected to burning over with a flamethrower. Heavy tick infestation may result from congregation of the animals at feeding, watering, sheltering and stabling places. These areas should be sprayed with a long acting acaricide like Barricade 5®, 2 to 3 days before introduction of the camels (Manefield and Tinson, 1997).

Q. Are psoroptic mange and sarcoptic mange one and the same?

No, these are different, caused by different mites. Psoroptic manage is caused by *Psoroptes cameli* in camels in Indo-Pakistan subcontinent. It is usually a relatively mild and superficial infestation with varying degrees of pruritis. It most frequently causes lesions between the mandibles, in the axillae, around the tail, on the mammary gland and on the prepuce (see sarcoptic mange). Organophosphate sprays (Barricade S®) be done at weekly intervals, 2 to 3 times. The animal should be thoroughly wet all over.

Q. Name the fly that causes myiasis. Discuss the disorder caused by this fly.

Probably the most important of the flies, which causes myiasis, is the nasal bot, *Cephalopina titillator*, a fly belonging to the family Oestridae of the order Diptera. The adult is short lived and rarely seen. The larvae, which hatch from eggs laid by the female fly in the camel's nostrils, are widespread, numerous and almost universally present in camel sinuses.

Later the emerging larvae migrate to the naso-pharynx. After completing their development, the larvae are usually removed by sneezing. The characteristic symptoms are bleeding from the nose, nasal discharge due to swelling and secondary infection of the respiratory tract and respiratory distress. If the larvae penetrate the turbinate bones, nervous symptoms, including difficulties in movement and apparent fear of people even already well known to the camel, may also result. Diagnosis is based on presence of neurological signs. Rabies should be kept in mind as a differential diagnosis. If necessary, treatment with several available injectable antiparasitic drugs can be effective. *Hippobosca camelina* a large and sturdy biting fly belonging to the Tabanidae family is specific to camel and is almost always found around camels, especially favouring their abdominal and inguinal regions. It is somewhat difficult to kill it by slapping or squashing. Its role in disease transmission, especially of trypanosomiasis, is not known but secondary losses due to stress and disturbance to animals are probably considerable (Wilson, 1998).

Q. Discuss the causes, clinical findings and treatment of gastrointestinal disorders in camel.

With pastoralists and nomads, the most commonly occurring diseases of the gastrointestinal tract in adult camels are mostly related to severe endo-parasitism, sudden diet changes and some specific diseases such as chronic trypanosomiasis and plant poisoning. Most cases of diarrhoea related to endo-parasitism and diet are seen at the beginning of the rainy season. The onset is usually acute and 20 to 30% of the adult animals of a herd are involved. Mortality is usually low. Neonatal calf diarrhoea is mainly caused by bacterial infection including *Escherichia coli* enterotoxaemia and salmonellosis. Morbidity can be up to 30%, but without immediate and proper treatment, mortality can be very high. Poor management practices such as no or inadequate colostrum feeding, unsanitary feeding, faecal contamination of watering sites facilitate disease outbreaks. Dietary diarrhoea caused by ingestion of excessive quantities of milk is rare in young calves, since suckling intervals are strictly controlled by herdsmen.

Faecal water content increases in diarrohea resulting in the frequent passage of loose faeces. Gross examination of faeces may show alterations in colour, odour and presence of blood, mucus, parasites and undigested feed or sand. Underlying mechanisms for increased faecal water content can be

hypersecretion, exudation, altered motility, malabsorption and osmotic retention of water. In acute diarrohea, excessive amounts of fluid and minerals are lost as indicated by sunken eyeballs, decreased skin turgor and sticky mucous membranes. Persistent diarrhoea also results in continuous soiling of rear quarter (tail hairs get matted with dried faeces and progressive loss of condition (hump is reduced to nothing, ribs become prominent and there is general muscular atrophy).
Animals usually become debilitated due to acute bacterial diarrhoea and show additional clinical signs such as fever, abdominal pain, anorexia and general depression. Cases of chronic diarrhoea show a persistent loss of weight, decreased productivity, but grazing activity and feed intake may still be near normal. An etiological diagnosis is usually difficult, but affected age groups, seasonal incidence and type of diarrhoea might be helpful to identify the underlying cause. If definite etiological diagnosis is needed, samples must be submitted for laboratory analysis.
Dietary induced diarrhoea usually resolves itself, if diet change is corrected and usually does not require any specific treatment. However, if endo-parasitism is the cause of diarrhoea, treatment with a brodspectrum anthelmintic and general improvement of sanitation regarding clean water holes and clean night enclosures will limit spread and reinfection. To treat the diarrhoea caused by bacterial or viral infection, long-acting antibiotics should be accompanied by oral replacement of fluids, supplemental feeding, good sanitation and, to limit spread, isolation of the affected animal. Despite the prevalence of dietary and parasitic induced diarrhoea, the importance of clinical work-up and at least the consideration of different possible causes should not be overlooked before and during treatment. Careful monitoring of response to treatment, condition of the animal, spread of the disease etc. is mandatory and will aid making and confirming the diagnosis.

Q. Give symptoms and treatment of colic in the camel.

Initially the camel manifests colic usually in the form of varying degrees of restlessness while in sternal recumbency. Rolling from side to side may be exhibited. Ballottement (a palpatory manoeuvre to test for a float object such as a foetus) and prodding of the abdomen will be resented. Intensification of pain is characterised by rolling and cramped (painful spasmodic muscular contractions) repetitions of rising and couching. At this stage the heart rate will be >60 (normal 30 to 40).

Every effort should be made to determine the underlying cause of the colic and to treat that condition. When abdominal sounds are spasmodically augmented, Buscopan Compositum, 20 ml IV in adults, usually gives good relief. Occasionally, in severe cases of colic associated with gastrointestinal obstruction, Rompun 100, 0.5 to 1.5 ml IM injected every 4 hours, has been found useful. Along with Tympanyl-liquid paraffin may be administered to relieve obstruction.

Sand Colic: Ingestion of sand may occur under certain circumstances such as haemonchosis, insufficient salt intake and boredom. It should be suspected as a cause of colic when tethered camels are not muzzled and faeces contain appreciable amounts of sand. Sand colic is difficult to treat when large amounts are present. Dosing with Methyl cellulose and Metamucil is effective. Metamucil 60 to 90 g once or twice weekly may be administered prophylactically but muzzling is easier (Manefield and Tinson, 1997).

Other allied gastrointestinal problems in camels and their most likely causes include:

- Abdominal distension: bloat due to diet, ingestion of excessive quantities of sand, obstruction of large intestine, watered camels, late term pregnancy.
- Anorexia: high ambient temperature, prolonged dehydration, fever.
- Constipation: impaction of forestomachs, bloat, obstruction of large intestines, complete recto-vaginal tear; prolonged dehydration.
- Impaired grazing/drinking: paralysis of tongue or dulaa, rabies, painful oral lesions caused by camel pox, FMD, BVD, contagious ecthyma, foreign bodies, decayed teeth, fractured mandible.
- Pain: bloat, peritonitis, enteritis, poisoning, abdominal hernia.
- Tenesmus (painful straining): endo-parasitism, genital tract diseases such as vaginal prolapse, vaginitis; recto-vaginal tear, urethral obstruction.
- Vomiting: behavioural display of stressed or furious camels when restrained.

Q. Are stiff neck and wry neck syndrome in camels one and the same thing or are different conditions? Justify your answer with reasonable explanation.

Stiff neck and wry neck syndrome in the camel are two different diseased conditions. The latter is characterized by a S-shaped deformation of the camel's neck. The onset of the disease is acute and sponataneous recovery without treatment is not uncommon. Apparently the condition does not appear to be painful and the animals behave normally. In severe cases gazing is impaired and animals lose condition progressively. Most commonly animals at weaning age are affected. The disease does not seem to be contagious. Systemic treatment with vitamin B complex hastens recovery but it is not clearly known that the disease is related to deficiency of vitamin B complex. Pastoralists resort to the traditional treatment of bilateral branding of the neck of the camel.
Stiff neck, on the other hand, is a distinctive disease condition having both acute and chronic forms. Clinical findings in the acute form appear similar to tetanus, whereas the described chronic form does not fit the clinical picture of tetanus. The acute form is characterized by stiff neck, general rigidity of muscles and inability to open mouth. The acute form is quite often fatal and lasts 10 to 15 days with progressing signs. All age groups are susceptible. Since only single animals are usually involved, therefore the disease does not appear to be contagious. The condition, however, is very painfull. Spontaneous recovery is not uncommon, however, convalescence period is quite long.
There is permanent stiffness of the neck, head and neck are held in extended manner exhibiting severe pain. The chronic form lasts about 3 to 12 months. During this period the animals lose condition and eventually die. Nomads and pastoralists treat this condition by extensive branding of the neck region. Suggested differential diagnosis in chronic form has included rheumatism and muscular disorder during surra. Subluxation (partial dislocation) of the atlantoccipital articultion or other musculo-skeletal injuries to the cervical column have to be included in the differential diagnosis.
Since the acute form of the disease has many similarities with tetanus, therefore, it seems logical to discuss here about tetanus. Tetanus is a widespread disease in tropical and subtropical regions. *Clostridium tetani*, an anaerobic organism causes this disease. It is commonly present in soil or intestinal tract. Mortality due to tetanus is quite high. Recovered animals develop no immunity against reinfection. In wounds contaminated with soil containing clostridial spores, especially deep puncture wounds covered by scabs or dirt, a favourable anaerobic condition is created in which *C. tetani*

can multiply and grow. Upon stagnation of growth, autolysis of bacterial cell membranes occurs and neurotoxin is released which stimulates nerve endings. Incubation period is between 10 to 14 days. Characteristic symptoms are localized stiffness of the head and the neck muscles, generalized muscle rigidity, lock jaw and erect ears. External stimulation including noise, sudden movement and sensation of contact provoke sudden general spasms. Severity of spasms and outcome of disease depend on the amount of toxin released and animal susceptibility to the neurotoxin. Respiration rate and body temperature are increased. In mild cases recovery is possible. Fatal outcome is common in severe cases.

Application of dark eye patches and ear plugs is recommended to reduce exposure to external stimulation. Preferably affected animals should be put in a quiet and dark environment. However, if no such facility is available, the animal should be sedated. Before putting the animal there, the area should be inspected for any standing out bricks, rocks, or any protruding out nails to reduce the risk of injury during general spasms. Also, clean and soft bedding should be provided. The animal should be inspected for any wounds and treated accordingly. Tetanus antitoxin and antibiotics be administered systemically. Keep in mind the possibility of anaphylactic shock (a manifestation of immediate hypersensitivity) due to antitoxin. Animals responding to treatment should receive good nursing care during the recovery period (Schwartz and Dioli, 1992).

Q. Give the causes and clinical findings of facial paralysis in camel.

Common causes of facial paralysis in camel are direct trauma to facial branches of otitis medial or interna nerves and skull fractures into the petrous temporal bone. Paralysis is usually unilateral. Main clinical findings are immobility and dropping of the ear and deviation of the nose to the unaffected side. In permanent facial paralysis there is atrophy of muscles on the affected side. Treatment for acute cases includes administration of antiinflammatory drugs, application of hot packs and good nursing care plus use of appropriate nervine tonics.

There are some other nerve dysfunctions such as paralysis of the radial nerve after prolonged lateral recumbency, inability to get up after prolonged restraint with ropes in sternal recumbency, post-partum ataxia in first calvers with dystocia and transient paralysis of the tongue presumably related to vigorous manipulation of the tongue or resulting from trauma. Restoration of normal function in most of these cases depends on the extent

and nature of damage. However, good nursing care and persistent treatment can yield unexpected success.

Q. Discuss in detail the occurrence of ocular ailments in camels.

Ocular ailments are common among herded camels and are mostly of traumatic origin including blows, thorns and other foreign bodies. Most of the time one eye is affected. On pastures where vegetation consists mainly of shrubs and acacia trees, the incidence of trauma is high. Injuries also occur during the night, when the animals are confined in small enclosures usually built of thorny branches of acacia. Excessive rubbing due to irritation of the eye lid caused by fly or tick infestation can also lead to eye injuries and secondary bacterial infections. During the fly season, infestation with *Thelazia leesi*, a nematode can be seen. The eye worm is found in the conjunctival sac. It may cause conjunctivitis and hyperlacrimation. Eyelid inflammation is also seen with camel pox and contagious ecthyma infections. Occasionally eye infections result in impaired vision or complete blindness caused by corneal opacity and scars. Opacity of the lens is a common ailment among older camels. The etiology is not clear. Depending on the degree of cloudiness, vision can be partly or completely impaired. Such animals usually lose condition rapidly unless supportive help is available, since their grazing ability is seriously impaired. They are also at a higher risk of predation if not thoroughly guarded. Cases of temporary blindness in adult camels without apparent lesions have been observed. The animals recovered full eyesight after a few weeks. They showed photophobia and apparent blindness as indicated by insecure gait and walking into objects. This idiopathic (of unknown cause) blindness was thought to be related to previous severe outbreak of camel pox in the herd. Night blindness also occurs in camels but at a very low incidence. It has been seen in both sexes while otherwise they are completely normal.

Most eye ailments cause a lot of discomfort to the animal, which may result in reduced feed intake. There are signs such as hyperlacrimation, head tilt, wounds, swelling of periocular tissue, separation from the herd, seeking shade, extensive rubbing of the head, squinting, insecure gait and bumping into obstacles. Thorough examination of the eye will often reveal the cause. Superficial wounds of the eyelid and the periorbital region usually do not require any specific treatment beside wound cleaning, removal of any ticks present and prevention of fly-strike. Treatment of swelling and inflammation of the eyelids and secondary bacterial conjuctivitis caused by

camel pox or contagious ecthyma lesions includes cleaning of the eye and repeated application of topical antibiotic ointment into the conjuctival sac. Inflammed conjunctiva or keratitis due to foreign bodies such as sand, grit, thorns can be treated by careful removal of the foreign body and repeated application of topical antibiotic ointment. Furthermore, the animal should be kept in shade or a temporary eye patch placed over the affected eye. In case of severe pain as indicated by loss of condition, the short term use of analgesics is recommended. Feeding and watering of animals with temporary or permanent impaired vision should be done separately from the herd to prevent feed being taken by other animals. Also, the animals should be confined in an enclosure to reduce the risk of self inflicted injuries (Schwartz and Dioli, 1992).

Q. What are the usual sites and signs of snake bite in the camel? Suggest suitable curative measures.

Snakes can bite the camel on the legs, udder, lips and any part of the body while it is sitting or browsing. If the bite is on a hairy part of the body, it is often hard to locate it.

There are so many types of snakes, thus the signs depend on the type of snake and the body part bitten. The camel bellows loudly and for a long time. It becomes restless and loses coordination. It stops grazing. There is swelling at the site of the bite, foaming from the mouth and protruding tongue. The bite wound may bleed when bitten by certain types of snakes. If the bite is on the udder, the affected quarter may ultimately slough off. The bite in the throat leads to death.

To treat a case of snake bite, tie a tourniquet (a tight rope or bandage) above the bite. Widen the location of the bite using a knife and allow it to bleed. It is hoped that the poison flows out together with the blood. Treat the wound like any other wound. Apply an electric shock as soon as possible after the animal is bitten. Put the affected areas (usually a leg) on the ground (to earth it electrically). Use a cattle prod or a lead from a car spark plug to apply an electric shock to the bite for 1 to 2 seconds. Repeat 4 to 5 times at intervals of 5 to 10 seconds. If treated soon enough (within 30 minutes of the bite), all pain disappears in 10 to 15 minutes. If available, inject antihistamines and antivenin (to counteract poison).

Q. What do you know about red urine in camels? Discuss in detail.

Red urine also called haematuria (Rut Mootra). Red urine is caused by blood in the urine. There are several causes of excretion of blood mixed urine. However, it is not a common problem in camels. The urine may have

a tinge of blood or it may be deep red. Sometimes there are signs of discomfort in the belly and straining while passing urine.

Different causes of this problem are: infections of kidneys or other parts of the urinary tract, damage to kidneys caused by a blow on the back, wounds to the scrotum or penis, possibly caused by bites by other males during the rut season, bladder stones, parasites in the kidney and plant poisoning.

If red urine is due to bladder stones: inject 20 to 30 ml of Buscopan Compositum or 20 to 30 ml of Novalgin into the muscle or vein and treat as for infections. If red urine is due to an infection, inject an antibiotic such as ampicillin (10 mg/kg body weight intramuscular twice a day for 7 days or norfloxacin (5 mg/kg body weight 1M for 7 days). Give the camel plenty of water to drink (drench with water if it does not drink) (K. Rollefson *et al*., 2001).

When haematuria is due to an injury, press a cold, damp cloth on the wound and then apply an antiseptic dressing. Inject a systemic coagulant such as carbazochrome or vitamin K. Give a urinary antiseptic such as nitrofurantion (4 g twice a day by mouth) for 10 to 15 days. Inject an antiinflammatory drug such as phenylbutazone (10 mg/kg body weight) once a day for 7 to 10 days. To prevent secondary bacterial infections, inject an antibiotic such as ampicillin (10 mg/kg body weight twice a day IM for 7 to 10 days. As a preventive measure avoid injuries to the kidney region i.e. the camel's back behind the hump.

Q. What are the salient signs of sunstroke in the camel. Suggest appropriate preventive and curative measures for this ailment.

In very scorching hot and/or humid weather, an overworked and heat exhausted camel may fall down and lose consciousness. It may die immediately, or remain weak and go off feed and water, possibly dying later. This problem is encountered commonly in draught camels and animals that are stall-fed.

The more commonly observed signs are: convulsions, dizziness and sudden loss of consciousness, off feed and water, no response to movements nearby. The animal seeks shade and hides its head in bushes. Scorching heat and deficiency of minerals and vitamins in the feed are the usual causes.

Preventive Measures: Do not use the animal for long hours of draught work in very hot and/or humid weather. Provide mineral and vitamin supplements to stall-fed camels. Provide a drink made of 1 to 2 kg of ground sorghum once a day.

Curative Measures: Put the animal in the shade: Pour cold water over its head and body. Give a drip of 7 to 10 litres of normal saline solution per day for 3 days. Give a drip of 3 litres of oral rehydration liquid (9 g salt, 50 g of sugar and 10 g of sodium bicarbonate dissolved in each litre of water) for 7 days. Inject the following each day: vitamins ADE IM for 3 days, dexamethasone (40 mg into the vein for 3 days) and analgin or paracetamol (e.g. paracetol 30 ml IM for 2 days. Do not give corticosteroids such as dexamethasone to a female camel during the last 4 months of pregnancy because abortion can take place (K. Rollefson *et al*., 2001).

Q. Define allergy and give the common signs of allergy in one-humped camel.

When the body over-reacts to a certain substance, this phenomenon is called allergy. The substance can enter the body if it touches the skin, or is injected, or the camel eats it or breathes it in. Either the whole body can be affected by allergy or only the part that comes into direct contact with the antigen. Some animals have allergies to certain substances, while others may not be affected at all.

Q. Write down the possible causes of allergy and suggest suitable treatment of this problem in camels.

Body overreacts: to injection of certain medicines e.g. in case of trypanosomiasis, to certain types of vaccines especially those with oily base; to insect bites (such as wasps, bees and ants) and to certain types of feed. To treat such cases inject an antihistamine, inject corticosteroids such as dexamethasone (do not give these to female camels during the last 4 months of pregnancy because they can cause abortion). When one part of the body is affected, apply creams containing prednisolone to the affected parts.

Q. Discuss dry coat syndrome, giving its causes, signs and treatment.

This problem is commonly reported by camel herders. It is also named as anhidrosis and hypohidrosis. Dry coat syndrome is common in the summer. Although the exact cause is not known but lack of enough salt intake, overwork and improper rest may lead to dry coat syndrome.

Important signs are: reduced amount of sweating or none at all. A normal draught camel will start sweating within 30 minutes of work during the summer. Unwillingness to drink (a typical sign) and eat, rapid loss of condition, the animal seeks shade, depression, fever more than 103°F (40°C) during the morning, possibly higher in the evening, rapid pulse and

breathing, breathlessness. The animal becomes tired quickly. The temperature stays high even when the camel is resting.

Treatment: Force the camel to drink or drench with water. Provide 0.5 kg salt in the feed or water every 4 to 8 days. Make a drench of ground garlic, ginger, Kalizeeri (*Vernonia anthelmintica*), skimmed milk, jaggery and common slat. Give 500 ml of this drench twice a week. Drench with 250 ml of Taramira (*Eruca sativa*) oil. In addition to the traditional treatment, modern treatment suggests: rest for 1 week. Make a solution of 120 to 240 g of commercial oral rehydration salts, plus 0.5 kg of glucose (sugar) or prepare 3 to 4 litres of oral rehydration fluid. Drench once a day for a week. Give 5 to 6 litres of Ringer's lactate-dextrose solution and vitamin B-complex as a drip once a day for 1 week. Give 2 to 3 g of vitamin E in the mouth once a day for 1 week.

Q. Write a note on urolithiasis.

In the male, ascending infections can lead to caculus formation. Urolithiasis has also been associated with a diet high in concentrates. The calculi usually lodge in the urethra just before or in region of the sigmoid flexure. If the blockage caused is partial, the signs are frequent passage of small amounts of urine or prolonged urination time. The bladder, if intact, is likely to be full and the animal apparently incontinent. It is wise to confirm that rupture of bladder has not occurred before attempting relief by urethrotomy. In the female, uroliths have occasionally been seen during routine trans-rectal ultrasonic examination. These would only cause a problem if impacted into the neck of the bladder. It may be possible to massage them back into the bladder fundus from this site. Urethrotomy may be performed above or below the scrotum. The lower site is preferred since there is less haemorrhage and less problem from subsequent urine scald. The wound may be allowed to heal by granulation and general wound treatment.

Q. Define wounds. How would you proceed for the treatment of a basic wound and an infected wound?

Wounds are injuries that cause breaks in the skin. In case of deep wounds, tissues underneath the skin are also involved. Wounds may be shallow such as scratches caused by thorns or deep such as a spear wound. The type of wound depends on what caused it. Wounds often heal slowly, especially if they are infected. Camels are very prone to wounds.

Treatment of Basic Wounds: Clean the wound with salt water (mix 2 teaspoons of common salt with a bottle of clean boiled water or with diluted vinegar or sodium bicarbonate, diluted the same way as the salt. Clean the wound with pyodine. Renew the dressing once a day until the wound heals. Clean the wound with an antiseptic, cut out any dead flesh and sew the skin closed with a needle and suitable thread. Do not sew any old or infected wounds. To stop bleeding, apply tincture benzine or a 10% solution of alum or the juice or flesh of *Aloe* leaves.

Treatment of Infected Wounds: Cut off the hair around the wound. Clean the wound with hydrogen peroxide. Pick out, if any, maggots either with a forceps or by applying a ball of cotton soaked with phenyl or turpentine oil, for 10 minutes or dip a swab of cotton wool in Maggacite and pack into the wound for at least one day. Next day clean the wound and remove the dead maggots. Make sure any pus can drain out by cutting a slot into the skin. Remove dead tissue from the edge of the wound with a scalpel or clean sharp knife. Flush the wound with an antiseptic lotion. Apply an antibiotic dressing. If the animal is valuable, give it a shot of anti-tetanus serum. Deep wounds should be treated with an antibiotic used against mastitis. Squirt the antibiotic into the wound through the nosel of the antibiotic tube (in some countries these antibiotics come in a syringe with a blunt point instead of a needle). If the wound is deep and produces pus, use the above treatment, and flush it out with an antiseptic once a day for several days (K.Rollefson *et al*., 2001).

Q. What are the various causes of wounds in camel and the factors that further complicate the wounds? Suggest suitable wound treatments.

Injuries of varying severity are a common problem in camel management. Browsing areas mainly having shrubs, acacia trees, other thorny vegetation and stony ground often become source of skin, foot pad and sternal pad wounds. In addition, predators, venomous snakes and intertribal enmities can also contribute to a higher incidence of wounds. During the rutting season, fighting wounds on withers, hump, front legs and scrotum among male camels are a common problem. Occasionally female camels are accidentally injured by breeding males during courtship. The foot pad and the pedestal pad are predisposed by their function to penetration by foreign bodies such as thorns, nails, sharp pebbles. Humid and wet weather increases the liability by softening the horny tissue.

Lesions can be superficial or involve deep tissue. Factors such as time lapse since injury, further contamination with soil, blood supply, presence of necrotic tissue, foreign bodies, flystrike greatly influence physical appearance. Wounds caused by penetrating foreign bodies are usually small and deep and are thus easily overlooked, especially foot pad and pedestal pad lesions. Foot pad lesions usually result in lameness, hot and painful swelling and reluctance to move. Grunting in the act of rising or sitting down suggests a pedestal wound. Pedestal wounds can impair reproductive performance. Affected male camels show a decreased libido, since weight bearing during copulation is done mainly by pedestal pad. Biting wounds can either appear as small puncture wounds, extensive laceration or even amputation of soft tissue. A bite from a venomous snake is characterized by two small puncture wounds. Bleeding may be minimal. If animal survives, extensive tissue swelling develops followed by local tissue necrosis. Anti-venom serum should be administered immediately.

While undertaking the treatment of a wound, an assessment needs to be made of the extent of lesions, status of blood supply and the time lapsed since injury. Primary closure should not be undertaken in the case of grossly contaminated wounds, where excessive tension will result from closure e.g. wounds close to joints and where dead spaces are present. These wounds are left open, debrided, a drain placed, broad-spectrum antibiotics administered systemically and allowed to heal by second intention (healing by granulation from base and both sides towards surface). Since all wounds are predisposed to fly-strike, application of insecticidal preparations should always be included in the treatment protocol. Biting wounds must be opened and the wound cavity explored, since biting wounds usually result in extensive trauma and contamination of deep tissue. These should be flushed with diluted iodine or a sterile saline solution. Prognosis is generally good.

Q. What care needs to be observed in treating wither wounds, nasal peg and pedestal pad wounds?

Vigorous treatment is necessary for proper healing of these three wounds. Any neglect can render the animal useless. Recurrent contamination, reopening of the wound by birds or brushing tree branches and insufficient drainage are common, especially in case of wither wounds. After dressing the lesions with pyodine and antibiotic wound powder, these must be covered with adhesive plaster (or protective bandage) so that the lesions are not recontaminated or reopened by birds. Treatment of an injured pedestal

pad presents a serious challenge. Position and function of pedestal pad lead to continuous soiling and irritation of the wound. To prevent this a dough shaped bandage can be applied. Thus the pedestal pad no longer comes in contact with soil when the animal lays down. Abscessation of the pedestal pad usually results from deep pedestal pad lesions and again has to be treated vigorously, since secondary infection of the chest cavity is possible from fistulas of migrating foreign bodies. Good drainage is very important. Prognosis is guarded, but good nursing care, dressing with pyodine and rest have yielded successful results. In neglected cases excessive formation of fibrous tissue results in an enormously enlarged pedestal pad. Such cases then require surgical amputation. Deep solar wounds also require vigorous debridement, flushing of the wound canal, removal of any foreign bodies, use of protective bandage and rest for early recovery of the animal.

Q. Write a note on saddle sores (saddle gall).

Riding as well as baggage camels may be affected by saddle sores. The skin where the saddle presses becomes raw or dry. It can take the form of an abscess. When the saddle is put on, the animal feels pain. Continuous rubbing and pressure from the saddle damages the skin and tissues underneath. Pecking by birds may keep the sore open. For treatment restrain the animal; preferably sedate it. Using a scalpel, open the sore to drain out the pus and remove the dead tissue. Put magnesium sulphate powder in the hole. Flush daily for 3 to 4 days with 0.1% solution of potassium permanganate. Then put in some more magnesium sulphate powder. When the wound begins to heal, apply an antiseptic, fly repellent ointment. Cover it to protect from birds. Inject a broad-spectrum antibiotic for one week. Do not put the saddle back on until the sores have healed.

Q. What is an abscess? Discuss abscess formation in camels.

An abscess is a circumscribed collection of pus surrounded by a wall of fibrous tissue. Abscess formation is a slow process. At the site of injury a hot and painful swelling develops indicating inflammatory tissue reaction. The presence of pyogenic bacteria or an irritant solution leads to various amounts of pus formation resulting in gradual enlargement of the abscess. Initially it is firm but during maturation becomes soft. At this stage spontaneous rupture may occur discharging a thick and viscous pus. Due to the excessive formation of fibrous tissue, drainage is usually insufficient and recurrence of the abscess and prolonged treatment are common.

Invasion of the organism into the blood or lymphatic system can result in internal abscessation, septic polyarthritis, joint ill and septicaemia.

Singular or multiple external and internal abscesses are a common health problem in camels. Several organisms have been isolated from abscesses such as c*orynebacterium sp*., *streptococcus sp*. *staphylococcus sp*., *pseudomonas sp*. and *actinomyces sp*. In adult animals abscessation is usually a common sequel to traumatic skin penetration. Infected fighting wounds, puncture wounds caused by thorns, wounds from predators, saddle sores, microlesions caused by ectoparasites and faulty or non-sterile administration of drugs can lead to single or multiple subcutaneous abscess formation Abscessation of lymph nodes is a common feature in camel. Furthermore, a diseased condition resembling caseous lymphadenitis occurs mainly in camels over 3 years old. Cold, painless and closed abscesses are present commonly stabilizing at about the size of an orange. However, the etiology remains unclear. In neonate camels, multiple subcutaneous abscess formation and joint ill is a common sequel to neglected umbilical cord infections. Joint ill is an important disease of neonate camels in which bacteria colonize joint spaces. Tarsal and carpal joints are most commonly affected.

Improved management and sanitation are mandatory. Affected animals should be treated by surgically excising the abscesses. Proper drainage, irrigation with antiseptic solution such as diluted iodine, pyodine or potassium permanganate solution and application of insecticidal preparations to prevent myiasis are essential parts of treatment. Hydrogen peroxide solution can be used in the initial treatment to dissolve and break up the abscess core. Application of petroleum jelly on the skin below the incision is helpful to prevent seepage induced excoriation (abrasion of the skin). In addition, systemic application of broad-spectrum antibiotics in cases of joint ill and septicaemia is necessary. Surgically incised simple abscesses usually show good healing.

Post-Mortem Examination

Q. Give an overview of the anatomy of the camel in such a manner that can be helpful to the field or farm worker in conducting post-mortem examination.

Skeleton: The skull of the camel resembles that of a horse. The most striking feature is a prominent projection of the occipital bone to which the powerful nuchal ligament is attached to support the weight of the head and the neck. The vertebral column of the one-humped camel is kyphotic

(having increased convexity in the curvature of the thoracic spine) and has seven cervical, twelve thoracic, seven lumbar, five fused sacral and 15 to 21 caudal vertebrae. The sternum consists of seven sternebrae. There are 12 pairs of ribs, of these four are asternal. The asternal ribs are bent backwards, the last one at an angle of approximately 45 degree thus enclosing a larger portion of the abdominal cavity. The limbs are long and slender. Radius and ulna as well as tabia and fibula are completely fused. There are two toes with distinctive nails and no vestigial digits. The distal phalanges of each toe are supported by digital cushions consisting of adipose tissue encapsulated in connective tissue. These are supported by thick layers of connective tissue and the thick undivided sole.

Skin: It is thick, tight and relatively immobile. There are only a few subcutaneous elastic connective tissue patches such as at the withers, the cranial medial foreleg, the abdomen, the caudal lateral hindleg, where subcut injections can be applied. There are four modified epidermal structures (callosities), situated at carpal, elbow and stifle joints, and at the sternum. These are the sites where the camel comes in contact with the ground when in sternal recumbency and consist of dark horny substance. The skin cover over hump is elastic. It contracts or expands easily with hump, but remains rather tight at all times. The hump itself consists mostly of fat and fibrous connective tissue and its size depends mainly on the nutritional status of the animal. The camel has no other subcutaneous fat deposits of any importance.

Topography of the Viscera: The lungs are occupying the major portion of the thorax. To view the heart properly, the cranial lobe of lung needs to be removed. The compartmented stomach plus spleen are the prominent organs on the left side upon opening the abdomen. The heart is visible on the right side only when the lung is removed. When abdomen is opened, small intestines appear to be the major organ. To see the liver properly, the last three ribs have to be removed. The right kidney is more cranially situated than the left one.

Respiratory System and Heart: The nostrils of the camel are slitlike and can be voluntarily closed against the entry of sand and dust, and still be actively opened to provide an adequate airway. The trachea is wholly cartilaginous and is necessarily quite long (1.3 to 1.5m) in adult camels. The pleural cavities are completely separated. The lungs are not lobed. The right lung is larger than the left. In many camels there is an os diaphragmaticus. In the galloping camel it would allow the

forward/backward movement of the viscera to assist respiration without impeding venous return. The diaphragm connects to the 10^{th} through 12^{th} ribs and it often contains a floating bone (os diaphragmaticus). The heart has a pointed shape. It is situated between the fourth and fifth intercostal space on the left side, whereas on the right side it is between the fourth and sixth intercostal space. The pericard is quite thick and non-transparent. It is white in colour. The pericardic fluid is clear, odourless with the viscosity of water. The total amount is 3 to 10 ml.

Digestive System: The camel has a prehensile, split upper lip, the lower lip is slack, often pendulous. The upper jaw has a tough dental pad. The oral mucosa are pigmented. Large conical and buccal papillae are present. The soft palate (dulaa) in males has an expandable diverticulum. Protrusion of the inflated dulla is part of the rutting behaviour. The tongue is quite long and spatulate in shape. The oesophagus runs left of the trachea. The stomach consists of three obvious compartments. Compartment 1 acts and functions much as does the rumen in the true ruminant. Compartment 2 corresponds to the true ruminant's reticulum. Compartment 3 is a relatively long tubular organ and may be regarded as a combined omasum and abomasum. The latter is a relatively small terminal portion. Compartment 1 occupies the left side of the abdomen, compartment 2 (reticulum) is to its right, the omasum (compartment 3) extends cranioventrally and then caudally from below the reticulum and terminates in a relatively small abomasum (part of compartment 3). The small intestines have a total length of 40m, while the large intestines are 19.5m. The crescent shaped spleen is situated in the left flank in close proximaity to the left kidney. The proportion of interlobular connective tissue is quite high. The malphigian corpuscles are visible on gross inspection. The spleen is attached to the left dorsocaudal wall of the rumen (not anterior as in buffalo, cattle, sheep and goat) and to the greater omentum. Its weight in the adult camel is about 0.6 to 1 kg. The pancreas has one pancreatic duct which joins the common bile duct near the duodenum. The left lobe is larger.

The camel's liver is dark brown when fresh and weighs 6.5 to 10 kg in the adult. It is situated mainly to the right of the abdominal midline, in contact with the diapragm anteriorly and protected by ribs 5 through 12. The dorsal border is thick and has a concave renal impression, which accommodates the right kidney, an oesophageal notch and a vena caval groove. The lobes are vague but lobules are quite distinct on the visceral surface. There are present many narrow 'knife cut' fissures on both surfaces. There is no gall

bladder. The two hepatic ducts unite to form a common bile duct 10 to 11 cm in length. The pancreatic duct joins the common bile duct before it enters the duodenum. Tubercular and other abscesses and hydatid cysts may occur in liver.

Kidneys: They are smooth and bean shaped. They are retroperitoneal and held against the dorsal abdominal wall. The right kidney is slightly longer but slightly less in mass than the left (1.08 kg and 1.13 kg respectively). It is situated below the 2^{nd} to 4^{th} lumbar processes and its cranial pole occupies a corresponding hepatic depression. The left kidney is situated below the last three lumbar transverse processes and it is in contact with the spleen. It can be palpated rectally and visualized by rectal ultrasonography. The hilus of both kidneys is directed medially. The cortex and medulla are distinctive and by volume have a ratio about 1.3:1.

Endocrine Glands: The thyroid gland shows a marked seasonal fluctuation in size and weight. In most animals an isthmus is present. It is situated a few centimeters from the base of the mandibula. Again, the adrenal glands show a great variation in size and shape. The cortex is light brown and the medulla brownish yellow. In camels, the medulla may extend as irregular cords into the cortex. The right adrenal lies adjacent to the right crus of the diaphragm and is attached to the vena cava. The left adrenal is flat, discoidal shaped and covered by a thin capsule, whereas the right adrenal is triangular and covered by a strong capsule. The left lies 8 to 10 cm in front of the left kidney. The ratio of cortex to medulla is approximately 4:1. Females tend to have marginally heavier adrenals than males, as it is in many other species. The pituitary is a small, pea shaped organ. Morphometric values of some of the internal organs, typical for a healthy adult camel, are given in Table 35.

Table 35. Morphometric values of some of the internal organs of a healthy adult camel

Organ	Colour	Weight (kg)	Length (cm)	Width (cm)
Heart	dark brown	1.5 – 2.0	22	19
Lungs	pink	5 – 6		
Spleen	greyish pink	0.6 – 1.0	30 – 40	8 – 10
Liver	dark brown	6.5 – 10	60 – 70	35 – 50
Pancreas	pink	0.4 – 0.5	42	
Kidneys	light brown	1.08 – 1.13	19	10
Adrenal glands		(g)		

Right	greyish pink	15 – 37	5 – 8	3 – 5
Left	greyish pink	15 – 33	4	3.5
Thyroid	reddish brown	Fluctuates	3 – 8	1 – 4
Pituitary	Grey	3 – 4 g	0.8 – 1.2	

Source: Schwartz and Dioli (1992).

Male Organs: The penis is composed of fibroelastic tissue and has a postscrotal sigmoid flexure. When relaxed the penis is normally completely contained within a subabdominal prepuce. Anteriorly the penis hangs down within a triangular reflection of skin and other preputial tissue so that the terminal penis and the preputial orifice, point backwards. Urine is thus voided in a backward direction. The urethral opening is very small. The glanspenis is represented by the urethral process. Four vestigial teats are usually present on posterior part of the prepuce. The sigmoid flexure may be palpated just posterior to these teats. The testicles show a marked seasonal fluctuation in size, weight and texture. They are situated high up in the ischiatic arch. One testical tends to be smaller and relatively softer. There are two accessory glands, the prostate and the bulbourethral gland. Cryptorchism is not uncommon.

Female genitalia: The uterus is a T-shaped organ. The left horn is always larger than the right. Division between the uterine horns is pronounced and proceeds well into the uterine body. The uterine body is short (8 to 14 cm). In older multiparous females the uterus extends well into the abdominal cavity. The cervix has longitudinal folds and is 3 to 6 cm long. The cervical os never closes tight. The ovaries are relatively small (18-25 mm in dia), thin and oval shaped. In multiparous animals the existence of carpora albicantia cause the shape to be distorted. In young animals the ovaries are to be found caudal to the pelvic brim. Follicles develop peripherally and can be detected ultrasonically when they are 3mm in diameter or larger.

Udder: The udder is situated between the hind legs and is divided into four glandular quarters with four teats. Each teat has a pair of orifices and ducts. The right and left udder halves are distinctly separated by laminae mediales. The separation of front and rear quarter within each half is indistinct. The front quarters are usually larger than the rear. Presence of accessory teats is not uncommon. The udder size varies with stage of lactation. Machine milking of camels is being investigated.

Q. Give a tabulated comparison of some of the anatomical characteristics of the camel with those of bovines and horses.

Table 36. Comparative anatomical characteristics of the camel, cattle and horse

Organ	**Camel**	**Cattle**	**Horse**
Vertebral column	C7, T12, L7, S5, CD 15-21	C7, T13, L6, S4, CD 18-20	C7, T18, L6, S4 Cd 15-21
No. of ribs	12 (8:4)	13(8:5)	18(8:10)
Heart	pointed	round	pointed
Lungs	no fissures, pink colour	fissures, pink colour	no fissures, red colour
Diaphragmatic bone	yes	no	no
Stomach	3-compartment	3 forstomachs + 1 true stomach	1 true stomach
Small intestines	40 meters	27-49 meters	22 meters
Large intestines	19.5 meters	14 meters	7.5-8 meters
Colon	coiled	coiled	horseshoe shaped
Liver	6.5-10 kg dark brown	4.5-10 kg light brown	5 kg brown red
Gall bladder	none	Yes	none
Spleen	crescent 0.8-1 kg dark purple	long oval 0.7-1.2 kg grey purple	crescent 1-2 kg steel blue
Kidney	bean shaped	lobulated	right: heart shaped left: bean shaped
Capsule	very adhesive	non adhesive	non adhesive
Pancreas	0.5 kg one pancreatic duct	0.6 kg one pancreatic duct	0.3-0.5 kg two pancreatic ducts
Male genitals			
Preputium	caudally	cranial	cranial
Penis	fibroelastic	fibroelastic	musculocavernous
Location	ischiatic arch	pendulant	pendulant
Female genitals			
Uterus	bicornuate T-shaped	bicornuate	biocornuate Y-shaped
Body	8-14 cm		30 cm
Oviduct	25-28 cm	20-28 cm	20-30 cm

Horns	left larger than right	35-45 cm	22-25 cm
Vesicular gland	none	yes	yes
Udder			
Quarters	4	4	2
Teats	4	4	2
Ducts per teat	2	1	2
Skin callosities	yes	no	no
	(carpal, elbow, stifle and sternal)		

Source: Schwartz and Dioli (1992).

Q. What are the objectives of performing necropsy or post-mortem examination?

Post-mortem examination is done with the following objectives in view:

i) To assess whether a carcass is safe for human consumption or not.

ii) For diagnosis and control of diseases.

iii) For research purposes, to determine the effects of various drugs or treatments on various body systems.

Q. What guidelines have necessarily to be kept in view while conducting a post-mortem of the camel?

For useful findings it is very important that the time lapse between death and beginning of the post-mortem (PM) examination should be as short as possible. PM carcass deterioration starts much sooner under high ambient temperature. The gastrointestinal tract, adrenal glands and the central nervous system are among the first organs to show signs of deterioration. Characteristic signs of beginning PM deterioration are desquamation (shedding of epithelium) of epithelium, liquidisation (adrenal medulla and central nervous system) and general friability of organs (gastrointestinal tract, liver and kidneys). Pale, watery and cooked appearance of muscles is a sign of advanced PM deterioration. Valuable indicators to estimate time of death are rigor mortis, blood clotting and imbibitions (absorption of a liquid). Viability of endoparasites can also be a useful indicator e.g. *Cephalopina titillator* larvae die a few hours after their host has died. Rigor mortis is best assessed upon opening the heart. Prior to rigor mortis the left ventricle appears dilated and contains various amounts of red unclotted blood. During rigor mortis the left ventricle is contracted and nearly empty

of blood. After rigor mortis has passed by, the left ventricle contains dark haemolised blood.

Rigor mortis takes place and subsides more rapidly in animals that were either stressed or emaciated before death because of their already depleted glycogen storage in muscles. In ruminants a condition similar to bloat can develop by PM bacterial fermentation of ingesta.

Q. Necropsy examination results under field or farm conditions are based on what criteria?

These are based on visual examination, palpation, description of tissues, organs and their cut surfaces using morphometric (forms of structures of organisms) measurements assessed by gross inspection (Table 37).

Table 37. Check list for necropsy performance and gross inspection in the field or at farm

Items	**Findings**
Whole animal	Body condition e.g. obese, thin, emaciated
Skeleton	Abnormalities, fractures
Skin and membranes	1) colour 2) hair coat e.g. complete, length, clean
Muscle and fat	1) colour 2) consistency
Organs (heart, lungs, kidneys, spleen, liver, endocrine glands, genitals)	1) colour 2) weight 3) length, width, diameter 4) consistency 5) topography (only if displaced) 6) adhesions

	7) ratio of cortex-medulla (kidneys, adrenal) 8) ratio of ventricles to septum 9) foreign bodies (gastrointestinal tract) 10) float (lung tissue in neonates)
Fluid (all body cavities, all capsules)	1) colour, 2) amount, 3) viscosity, 4) odour, 5) foreign particles
Structural change	1a) type of lesion e.g. abscess, ulcer, tumour, haemorrhage, scar, wound, cyst 1b) depth of lesion e.g. superficial, deep 2) distribution e.g. localized, generalized 3) size and shape 4) amount or number e.g. single, multiple 5a) consistency e.g. firm, soft, liquid 5b) texture e.g. smooth, rough 6) odour 7) colour
Parasites	1) type e.g. tick, maggot, worm, hydatid cyst 2) amount or number 3) alive, dead

Source: Schwartz and Dioli (1992).

Variations from expected parameters such as size and weight provide helpful information to assess hypertrophy, hypoplasia (incomplete development) or aplasia (lack of development of an organ or tissue). However, it should be kept in mind that age, sex and environmental factors such as nutrition are known to influence physiologically size and shape of some organs. Moreover, standard units such as millilitre, litre, centimetre and kilogram should be used for morphometric measurements.

Q. Give details of an appropriate dissection procedure for post-mortem examination of a camel.

A complete history is taken including data about owner, patient, previous and present medical history and management. Performing the post-mortem with the animal on its left is usually faster and more convenient. Detail is as follows:

a) Lift the right hind leg as high as possible and cut towards and through the hip joint to allow the leg to be totally reflected back over the top of the sacral area. The knife blade should be directed posteriorly, away from the belly wall while performing these cuts.

b) Standing behind the cadaver the knife blade is inserted flat, cutting edge to the right, beneath the skin at the anterior edge of the initial cut in (a). Commencing adjacent to the mammary gland or penis, the skin is incised by cutting from inside out. The incision is developed in the direction of the animal's ventral midline and continued to the mandibular symphysis. The pedestal may be by passed on its immediate right or removed. Working back along this incision, the skin is reflected from the upper surface of the cadaver, along with the right fore limb, and thrown over the dorsal midline. Particularly in juveniles, the skin of the camel is tightly adherent in the flank region.

c) The abdominal cavity is opened by carefully incising the tissues immediately behind the last rib. The incision is enlarged; first behind the rib margin towards the xiphoid cartilage and then in another direction, upwards and backwards, close under and along the line of the lumbar transverse processes; and then down again to the udder or penis. The resulting inverted 'U' flap of flank tissues is reflected ventrally over the midline, thus exposing much of the abdominal viscera. If required, samples of gut may be obtained at this stage.

d) The diaphragm is incised near the right costal margin.

e) The right rib cage is removed. This is easily achieved in the mature animal by cutting the ribs close to their sternal attachment with a large pruning shear and then repeating this close to the vertebral attachments. These cuts can be made with a suitable saw or axe. If the operator prefers to reflect the right chest wall by breaking it back over the vertebral column, knife cuts should be made between every two ribs at least. Breaking back the chest wall as a whole is difficult if not impossible. In animals up to a few months old, the rib cartilages can be cut with a knife. Thus, the whole right side of the cadaver can be removed quite quickly and with a minimum of manipulation, all the viscera exposed to view. Specimens for laboratory examination are selected and obtained in the proper manner.

In case of necropsy inspection of animals slaughtered by traditional method the sequence given above has to be disregarded and PM examination is performed with slaughter sequence. If the animal has been slaughtered by Muslim method (cutting of major cervical vessels), the carcass appears overall paler and blood storage organs such as spleen will be contracted and empty (Schwartz and Dioli, 1992).

Q. Give an example of a post-mortem examination sheet with intemwise findings recorded therein.

The main purpose of presenting here this example is that in case a trained expert is not available when necessity arises to perform PM examination, a subprofessional person can do this job keeping this example in view. This is important to get a better insight into the epidemiology (study of the factors determining and influencing the frequency and distribution of disease) in camel populations and may be even more important, to evaluate the risks to public health arising from the camel as a domestic livestock.

Example of post-mortem examination sheet with findings recorded herein.

Part 1: Gross inspection before dissection		
Recorder	Kamal	
Owner	Karam Din	animal brought to Shahkot market, obviously sick
Death		10 a.m., slaughtered
Post-mortem		immediate, during butchering
Animal	Breed	camel
Condition	Body	almost good, well musceled
	Hump	Well developed, firm, round shape
	Haircoat	complete, hind legs soiled with faeces
	Udder	small, non-active, usual shape, firm consistency
	Teats	old healed wound close to orifice of right cranial (anterior) teat, other teats of usual shape
	Pads	small spherical deep pedestal wound, necrotic tissue at the edges and small amount of pus
	Nostrils	clean, dilated, no lesions
	Mouth	no lesions, normal

Body openings	Eyes	Eye balls sunken in, cornea surface wrinkled and slightly traumatized (small abrasions)
	Ears	normal
	Anus	slightly dilated, dark faeces around sphincter
	Vulva	disfigured, healed perineal wound
History	Symptoms	fever, diarrhoea, swollen glands, loss of appetite
	Onset	acute
	Duration	two days
	Herd	no other animal affected
	Treatment	none

Part 2: Inspection of internal organs		
Thorax	Serosa (any serous membrane)	transparent, adhesions between pleura and heart, multiple small haemorrhagic spots, three small abscesses close to adhesions
	Pericard	white, one adhesion to body wall, 5cc transparent watery fluid
	Heart	dark brown, 1.5 kg, firm, dark haemolised blood in left chamber, multiple petechie on surface
	Valves	tricuspid and mitral slightly thickened
	Trachea	inner mucosa lining red
	Thyroid	normal
	Lungs	red, puffy consistency, four small hydatid cysts
Abdomen	Serosa	Transparent
	Oesophagus	inner lining reddened
	Stomach	very small amount of feed, several small superficial ulcers in compartment 3
	Small intestines	dilated, liquid faeces
	Large intestines	dilated, multiple haemorrhagic spots, no formed faeces in rectum
	Liver	dark brown, 10 kg, one small abscess
	Pancreas	multiple haemorrhagic spots
	Spleen	red, swollen, 1.5 kg, multiple haemorrhagic spots
	Kidney	normal
	Adrenal	multiple haemorrhagic spots
	Bladder	medium filled, haemorrhagic spots on mucosa
Genital organs	Ovaries	nonactive, no follicles, several old corpora lutea
	Horns	no remark
	Body	no remark
	Cervix	dilated
	Vagina	no remark

Lymph nodes	All internal and external lymph nodes swollen, surface

	dark red
Nervous system	No remarks
Skeleton	No remarks
Muscles	No remarks
Diagnosis	Acute haemorrhagic septicaemia, probably pasteurella or Salmonella infection
Additional findings	One narrow, but deep and suppurating pedestal wound connected by a fistula to the thoracic cavity, adhesions between serosa and pericard, three abscesses in close vicinity to the fistula channel, three hydatid cysts in the thoracic cavity.

Source: Schwartz and Dioli (1992).

The most obvious findings in this example were generalized internal petechiation especially under the serosa of the intestines, the heart and the lymph nodes. In other cases gelatinous fluid may be present around the lymph nodes.

The picture may be complicated by signs of haemorrhagic enteritis and lesions of early pneumonia. In many cases the clinical and necropsy findings may not be conclusive and differentiation from anthrax, blackleg, septicaemic salmonellosis and acute leptospirosis has to be done by bacteriological examination. The absence of bloody discharge from the natural body orifices and a normal appearing spleen on post-mortem can be used to initially differentiate haemorrhagic septicaemia from anthrax. Infections of the gastrointestinal tract are not easily diagnosed by necropsy procedure alone. For definite etiological diagnosis, sample must be submitted for laboratory analysis. Infections of the respiratory tract present a similar problem in post-mortem diagnosis. Depending on the involved infectious agent, localized or generalized pathological lesions of the respiratory tract are found. However, typical signs of respiratory diseases of viral origin are often masked by secondary bacterial invasion. Bacteriological and histological examination should be performed if accurate etiological diagnosis is needed.

OVER ONE HUNDRED SPECIMEN OBJECTIVE QUESTIONS

Fill in the blanks:

Q. i) For microchip identification method, the chips are implanted in the nuchal ligament of the neck.

Q. In the equation P=G+E; P,G and E stand for phenotypic measurement of a trait, genetic effect of all pertinent genes and environmental factors influencing the trait respectively.

Q. A low correlation between genotype and phenotype indicates a low heritability estimate.

Q. DNA techniques should be exploited for future research e.g. in camel breeding, disease control, parentage verification, population differences, archeological studies.

Q. The hindlimbs of the camel provide the main forward propulsive force.

Q. Couching means…………………………………………………………

Q. The foot pad of camel is filled with fat consisting of 75% unsaturated fatty acids.

Q. An area or a structure that does not reflect ultrasound waves and does not produce an echo is called anechoic or nonechogenic.

Q. In camels, ovulation takes between 24 and 48 hours after mating.

Q. GnRH stands for Gonadotrophin-releasing hormone.

Q. The placenta in dromedary is diffuse in nature and not cotyledonous.

Q. In camel, about 99% pregnancies are in the left uterine horn.

Q. Ovulation in camel is mainly induced by coitus.

Q. Encircle the correct answer. The camel udder has: 5 teat ducts, 4 teat ducts, 8 teat ducts, 6 teat ducts, 2 teat ducts.

Q. Encircle the correct answer. Rabies is a: parasitic disease, bacterial disease, non-infectious disease, viral disease, zoonotic disease.

Q. Encircle the correct answer. Camel calves are found actively foraging by the age of: 2 week, 4 weeks, 2 months, 6 months, 3 weeks.

Q. Encircle the correct answer. The finest wool is obtained from the: Bactrian camel, baggage camel, Arabian camel, racing camel, dromedary.

Q. Encircle the correct answer. Camels deprived of water in 42°C environmental temperature lose body weight per day at about the rate of: 4%, 5%, 2%, 8%, 1%, 6%.

Q. Name all the keratinised pads found on the body of an adult camel. Elbow, knee, hock, stifle and chest pads.

Q. T/F: A lot of water is available in winter, therefore, the camel drinks 55 litres/day. Encircle accordingly.

Q. T/F: Female camel calves are provided more milk than male calves by traditional camel herders. Encircle accordingly.

Q. Which one is more productive: Milking the camel twice a day or four times a day?

Q. What is the recommended age for weaning a camel calf? Encircle the correct answer. 16 months, 360 days, 185 days, 40 weeks.

Q. Average gestation period in camels is 360 days, 12 months, 370 days, 56 weeks. Encircle the most correct answer.

Q. Perineal device is used in camel for what purpose? For acceptance of calf.

Q. Encircle the correct answer. Surgical castration in camel is performed to remove the: urethra, gall bladder, testes, kidneys, bladder.

Q. Which one is more prominent in camel: hindquarters or forequarters?

Q. Encircle the correct answer. Normal body temperature is higher in: (a) old camels. (b) young camels (c) adult camels.

Q. Encircle the correct answer. Body temperature in rutting camel is: (a) higher than normal (b) normal (c) lower than normal (d) subnormal.

Q. Encircle the correct answer. High temperatures in camel during morning are indicative of (a) milk fever (b) fever (c) oestrus (d) stress.

Q. Encircle the correct answer. Laboured breathing is always an indication of (a) dystocia (b) respiratory disease (c) congested sinus (d) anorexia.

Q. Is it possible or not to get stomach fluid samples from camel's stomach by passing a stomach tube? Yes, it is possible.

Q. Encircle the correct answer. Total blood volume in the camel is: (a) 930 ml/kg 309 ml/kg (c) 93 ml/kg (d) 39 ml/kg

Q. Encircle the correct answer. (a) Ovulation in camel takes place 36-48 hours after stimulation. (b) Ovulation in camel takes place 20-24 hours before stimulation.

Q. Among farm animals, which is the best adapted to hot arid environment? One-humped camel.

Q. What is the main mechanism by which the camel survives in the desert? Its ability to conserve body water.

Q. Is it a myth or truth that camel stores water in its hump or stomach? It is a myth and it has been disproved since long.

Q. Can all the animal species equally tolerate dehydration? No, the tolerance varies largely in different species.

Q. Due to dehydration, efficiency of use of water decreases in camel. Do you agree with this statement? No.

Q. Cattle would die in 4 days at a total body weight loss of 28%. Do you agree with this statement? Yes.

Q. Fill in the blanks. Low water turnover is a characteristic of arid adapted animals.

Q. Fill in the blanks. The camel produces about 16 litres/day saliva when dehydrated.

Q. To compensate, feed intake increases in dehydrated animals. Do you agree with this statement? No.

Q. Fill in the blanks. The camel is able to reabsorb water from alimentary camel when dehydrated.

Q. Under dehydration a relatively high osmolarity further decreases. Do you agree with this statement? No.

Q. Fill in the blanks. In comparison with other farm ruminants the response of camel to improved conditions is only one-eighth of that of cattle and one-sixth of that of sheep.

Q. Fill in the blanks. Wet hide of camel is about 10% of body weight.

Q. What is recycled urea? Recycled urea in reality is the same protein that is used more than once.

Q. Does the camel has gall bladder? No, it does not.

Q. What is the major site of water absorption in the camel? The colon is the major site of water absorption in camel's body.

Q. Plant species reaching the higher strata of the vegetation as a rule belong to which group? They belong to the dicotyledon group.

Q. Fill in the blank: Free ranging camels spend less than 5% of their feeding time near ground level.

Q. Correct the sentences. The scrotum is small in camel. It is attached high up between the four legs and does not hang below the udder.

Q. Correct the sentence. The glans penis in camel is rectangular. It is like a crochet-needle.

Q. Male camels become infertile when their testicles are heaviest (correct the sentence). It is the otherway round.

Q. Encircle the correct answer. (a) The camel is an induced ovulator (b) The camel is a spontaneous ovulator.

Q. Fill in the blanks. Mixing of bhoosa of two leguminous crops is called missa bhoosa.

Q. The gestation period in one-humped camel varies from 380-390 days. Fill in the blanks.

Q. Rut in camel can be induced by gonadotropin treatment and better nutrition. Fill in the blanks.

Q. What are the main objectives of determining age of camels? (i) For trading, (ii) For treating, (iii) For breeding.

Q. Do camels have incisor teeth in both jaws? Yes, in both jaws

Q. What is other name for canine teeth? Tushes

Q. Deciduous teeth of camels erupt after temporary teeth. Do you agree with this statement? No.

Q. Mare and she-camel are large animals having the same number of teats. Do you agree with this statement? No.

Q. Give the formula to calculate the average age at which most females leave the herd. (Age at first calving plus interval between parturitions multiplied by number of young equals the age at which most females leave the herd).

Q. On an average, what is the percentage of breeding females in a camel herd? 40 to 45%.

Q. Give the total number of deciduous and permanent teeth respectively in dromedary camel. Deciduous = 22; permanent = 34.

Q. What is the best branding method for pastoralist's camel? Hot-iron branding.

Q. What is the most appropriate posture for slaughtering a camel? Sternal recumbency.

Q. For examination, urine of camel can be collected through: (a) free catch (b) a catheter (c) a syringe (d) a suction pump. Encircle the most correct answer.

Q. Encircle the correct answer. Daily average output of urine in camel is: (a) 55 litres (b) 5.5 litres (c) 0.55 litres (d) 2.5 litres.

Q. Where on the body of the camel is located pre-scapular lymph node? In front of scapula.

Q. Encircle the most correct answer. Most convenient site for collection of blood is: (a) medial metacarpal vein (b) jugular vein (c) dorsal metarsal vein (d) femoral artery.

Q. Encircle the most correct answer. A preferred site for subcutaneous injection in camel is: (a) in front of the shoulder (b) under the belly (c) behind the stifle joint (d) at the back of the hump.

Q. Encircle the most correct answer. For intramuscular use, injected volumes per injection site in camel should not exceed: (a) 1 to 100 cc (b) 50 to 100 cc (c) 15 to 20cc (d) 40 to 60 cc.

Q. Fill in the blanks. A tourniquet is used to put pressure to raise a vein or to check bleeding.

Q. Fill in the blanks. The udder of the camel is divided into four glandular quarters.

Q. Fill in the blanks. The uterus of the camel is T shaped.

Q. Fill in the blanks. Important diseases caused by ectoparasites in the camel are: sarcoptic mange, dermatomycosis, tick infectation, fly infestation, nasal bot (myiasis).

Q. Fill in the blanks. Ticks commonly found on camels belong to the family Ixodidae.

Q. Fill in the blanks. The gallbladder in the camel is absent like that in horse.

Q. Encircle the correct answer. Curative measures after the disease is clinically evident are called: (a) chemotherapy (b) chemoprophylaxis (c) hydrotherapy (d) prophylactic therapy.

Q. Encircle the correct answer. *Trypanosoma evansi* is transmitted by biting flies belonging to genus: (a) Stomoxys (b) Tabanus (c) Philoliche.

Q. Fill in the blanks. A synonym for tapeworms is cestodes.

Q. Fill in the blanks. Sarcoptic mange in camel is caused by *Sarcoptes scabiei*.

Q. Fill in the blanks. Ivermectin is useful for mange.

Q. A synonym for pasteurellosis is Haemorrhagic septicaemia.

Q. T/F: Dehydration of camels occurs more commonly in arid regions. Encircle accordingly.

Q. Debridement means: Removal of necrotic tissue and foreign material.

Q. T/F: Separation of front and rear quarters of the camel udder is distinct. Encircle accordingly.

Q. After death of the camel, what organs are among the first that get deteriorated soon? Gastrointestinal tract and central nervous system.

Q. Fill in the blanks: Fluctuation in morning/evening body temperature in camel in summer can save it 4 to 5 litres water daily.

Q. Tenesmus denotes: Painful straining.

Q. Fill in the blanks. The clear liquid that separates from blood when it clots is called serum.

Q. Normal body temperature of humans is 37°C. What is the same in camel? 37.5°C.

Q. T/F: Encircle accordingly. Heart rate and breathing rate of the camel mean the same.

Q. What is the importance of center of gravity of the camel body? Give two points to indicate the importance of this center in the camel.

Q. Give the average birth weight, weaning and adult weights of camel breeds in Pakistan.

The average birth weight, weaning weight and adult weight vary from 33 to 50 kg, 75 to 135 kg and 550 to 700 kg respectively.

Q. What is the average age at first breeding in camels in Pakistan?

The average age at first breeding in Pakistani camels varies from 4 to 4.5 years.

Q. Give the average daily milk yield and lactation length in camels in this country.

The average daily milk yield and lactation length in camels in Pakistan range from 3.0 to 8.0 litres and 250 to 510 days respectively.

Q. What is the average length of dry period and calving interval in local camels?

On average, these vary from 275 to 325 days and from 715 to 785 days respectively.

Q. What is the average annual hair production from a Bactrian camel?

It is about 5.5 kg.

Q. What is the total population of camels in Pakistan?

According to FAO (2000), the population of camels in Pakistan is 1.2 million.

Q. Give percentage distribution of the camel population in various provinces of Pakistan.

Provincewise distribution of the camel population is as follows: Balochistan 36.43%, Punjab 33.51%, Sindh 22.76% and NWFP 7.30%.

GLOSSARY

a.i. Active ingredient.
AI. Artificial insemination.
Abdomen. The belly.
Abomasum. Fourth stomach of a ruminant.
Abortifacient. Substance that causes abortion or miscarriage,
Abortion. Miscarriage: when the foetus is expelled before it is due.
Abscess. A collection of pus in the tissue.
Acaricide. Chemical used to control ticks.
Actinomyces. A type of disease–causing bacteria.
Active ingredient, active principle, a.i. Ingredient or chemical component of a drug, which has a healing effect.
Acute. Critical, sudden and of short duration.
Aetiological. Relating to the origin of or cause of a disease.
Aetiology, etiology. The cause of a disease.
Afterbirth. Placenta and other membranes that come out after birth.
Agroecological zones. Areas which have similar physical and climatic features and in which farming systems can be expected to be similar.
Alimentary canal. The digestive tract.
Alimentary. Pertaining to, or caused by, food.
Allergen. Substance that may cause an allergic response.
Allergy. Hypersensitivity of the body cells to specific substances, such as an antigen or allergen, resulting in rashes or other reactions.
Ambient. The immediate surroundings (e.g. ambient temperature = the temperature in the local area).
Anaemia. Below-normal number of red blood cells and quantity of haemoglobin in blood.
Anaesthetic. A medicine that stops all feeling. It makes the animal (or the part of the body it is applied to) numb.
Analgesic. A medicine that reduces pain but does not cause numbness. ,
Androgen. A male sex hormone.
Anhidrosis. Absence of sweating (Dry coat).
Anthelmintic. Substance that removes intestinal worms from the host animal.
Anthrax. Disease caused by a bacterium called *Bacillus anthracis*.
Antihistamine. Substance used to treat allergy and colds.

Antibiotic. A chemical substance produced by microorganisms that kills (or inhibits the growth of other microorganisms.

Antibody. A protein in the blood that is produced in response to an antigen.

Anticoagulant. Substance that prevents or slows down blood clotting.

Antidote. A treatment which counteracts or destroys the effect of poisons or other medicines.

Antiemetic. Substance that relieves vomiting.

Antigen. Substance that may induce an immune response (e.g. bacteria, toxins).

Antiinflammatory. Counteracting inflammation.

Antipyretic. Substance that lowers body temperature to the normal level; used against fever.

Antiseptic. Substance that destroys or inhibits disease–causing bacteria.

Antispasmodic. Substance that prevents or relieves muscular spasms or cramps.

Antivenin. Substance that counteracts the poison from an animal, such as a Snakebite.

Anus. The opening at the end of the intestines where the dung comes out.

Artery. A vessel that carries the blood away from the heart to other parts of the body.

Arthritis. inflammation of joints.

Artificial insemination, AI. Breeding by putting semen into the vagina or uterus without sexual contact.

Ascariasis, Infestation by an intestinal parasite called ascaris (Internal parasites).

Ascarid. A roundworm nematode (a type of parasite) found in the intestines.

Astringent. Substance that shrinks tissues and prevents secretion of fluids from wounds.

Bacillus cereus intoxication. haemorrhagic disease.

Bacterium, bacteria. Tiny microorganisms, some of which cause disease.

Balling gun. Tool to apply pills, capsules and boluses.

Balm. A soothing or healing medicine.

Blackleg. Blackquarter.

Blackquarter. Disease caused by a bacterium called *Closlridium chauvii*.

Bladder. The organ that holds the urine.

Blister. A vesicle, a skin lesion.
Bloat. The build-up of gases in the stomach or intestines.
Boil. Infected, painful, hard swelling of the skin.
Bolus. A ball or tablet of medicine. **Branding**. Marking the skin with a hot iron.
Broadspectrum medicine. A medicine effective against several disease causing microorganisms.
Bronchitis. Inflammation of the bronchi.
Bronchus, bronchi. The pair of air passages at the end of the trachea, leading to the lungs.
Buffy coat. Reddish-grey layer in a centrifuged tube, consisting of white blood cells between the red blood cells and the serum.
Caesarean section. Operation to cut the uterus open and pull the calf out.
Calf diarrhoea. Diarrhoea in calves caused by too much milk or by a virus.
Camelid. An animal that is a member of the camel family or Camelidae.
Cancer. A malignant, cellular tumour.
Canines. The pointed teeth beside the incisors; they can grow very large in male camels.
Cannula. Tube attached to a trocar.
Capillary tube. Thin lube with a very small inside diameter.
Carcass. Dead body of an animal or slaughtered animal after skin removal.
Carrying capacity. The number of animals that can be kept permanently on a given area of land (usually expressed in terms of one hectare or one square kilometre) without causing degradation of the land and its vegetation and which ensures that all animals receive an adequate amount of feed for both maintenance and production (production can be growth, milk production, being pregnant etc (see also stocking rate).
Castration. Removal of testicles.
Catarrh. Inflammation of nose and mucous membranes.
Catgut. An absorbable, sterile thread made from the small intestine of sheep; used as a suture material.
Cauterization. The burning of flesh with a hot iron or a chemical,
Centrifuge. Piece of laboratory equipment that spins very fast. Used to separate parts of a liquid from one another, such as components of a blood sample.
Cervix. The narrow, front part of the uterus.

Cestodes. Tapeworms.
Chemoprophylaxis. Prevention of infection by diseases through the use of drugs before the onset of a disease; chemotherapy is treatment of a disease by drugs. A vaccine, strictly speaking, is a biological product but vaccination is usually considered to be a part of chemoprophylaxyis.
Chronic. Persisting for a long time.
Closed fracture. Broken bone where the skin remains intact.
Clostridiosis. Blackquarter.
Clostridium. A type of disease causing bacteria.
Cold struck. Wry neck.
Colibacillosis. Disease caused by a bacterium called *Escherichia coli*.
Colic. Pain caused by gas in the stomach or intestines.
Colostrum. Thick yellow milk, rich in antibodies, protein and micro-nutrients, produced by mothers after giving birth.
Compress. A dry, often warm, substance applied firmly to a part of the body.
Concentrate. A carefully formulated mixture of nutrients (grains, oilcakes having high protein and energy contents).
Concoction. A preparation from crude materials, made by combining different ingredients.
Congenital. Present at and existing from the time of birth.
Congested. Closely packed.
Congestion. Abnormal accumulation of blood in part of the body.
Conjunctiva. The membranes around the eyeball.
Conjunctivitis. Inflammation of the conjunctiva.
Constipation. Infrequent or difficult bowel movement with hard dung.
Contagious skin necrosis. A skin disease.
Contagious. Diseases which are readily passed on to others.
Contamination. Introduction of microorganisms, for example when using surgical instruments that are not sterile.
Contusion. Bruise, injury where the skin is not broken.
Convulsion. A violent, involuntary contraction of the muscles.
Cornea. The transparent part of the eyeball.
Corneal opacity. Whitish film on the eyeball.
Corneal ulcer. Injury of the cornea.

Corpus luteum. Part of the ovary that forms after ovulation and produces hormones during part of the heat cycle.
Corticosteroids. Type of hormones; their synthetic equivalents are used as drugs. Corticosteroid drugs are used to treat certain diseases and decrease inflammation and itching.
Corynebacterium pyogenes. A type of disease causing bacteria.
Crepuscular. Showing a preference for activity in dim light, around dawn or dusk.
Cud. The ball of feed that ruminants chew and then swallow again.
Culling. Selective removal (e.g. of animals for poor reproductive or growth performance).
Cyst. A closed sac or capsule containing a liquid or semisolid substance.
Decoction. Medicine made by boiling ingredients in water.
Decongestant. Substance that reduces congestion or swelling.
Defaecate. Passing of faeces.
Deficiency. A lack or shortage.
Dehydration. Lack of water in the body.
Dermatitis. Inflammation of the skin.
Dermatomycosis. Ringworm.
Dermatophilosis. A skin disease caused by fungus.
Dermatophytosis. Ringworm.
Dermoid. Egg-shaped growths on the skin.
Detergent. Cleansing substance.
Diagnosis. The determination of a disease. It includes the name of the disease, its cause, and the prognosis.
Diarrhoea. Frequent passing of thin, watery faeces.
Digestive tract. The tube through which feed passes: the mouth, oesophagus, stomach, intestines and anus.
Dipetalonemiasis. Disease caused by a parasitic worm called *Dipetalonema evansi*.
Discharge. Substance excreted by the body, such as PUS.
Disinfectant. A chemical that kills microorganisms.
Dislocation. Bone displaced from a Joint.
Diuretic. A drug or preparation that causes urination.
Dosage. The determination and regulation of the amount, frequency and number of doses.

Dose. The quantity of a medicine to be administered at one time.

Downer. Disease where a camel refuses to get up; can have various causes.

Drench. Forcing the animal to drink a liquid medicine

Dressing. Material used to cover and protect a wound.

Drip. Slow, drop-by-drop injection of a liquid into a vein.

Dromedary. Another name for the one humped camel; derived from the Greek for ‘to run’.

Dry coat syndrome. Anhidrosis, absence of sweating.

Dulaa. Protrusion of soft palate of camels.

Dysentery. Inflammation of the intestines, with liquid and bloody diarrhoea and painful straining.

Dystocia. Difficult birth.

Echinococcosis. Disease caused by small tapeworms (Hydatid disease).

Ecthyma. Infection of the skin with large pustular vesicles.

Ectoparasite. external parasite.

Eczema. Inflammatory skin disease characterized by redness, itching and formation of scales and crusts.

Edema. Oedema.

EDTA. A substance (ethylenediamine-tetraacetic acid) that stops blood from clotting.

Ejaculation. To eject semen during the act of sexual intercourse.

Electuary. A medicinal preparation consisting of a powdered drug made into a paste with honey or syrup or Gur.

Embryo. A new calf in the earliest stage of development. Becomes a foetus.

Emetic. Substance that causes vomiting.

Encephalitis. Inflammation of the brain.

Endogenous. Internal; arising from inside the animal rather than from the outside.

Endoparasite. Parasite that lives inside the body (in the intestines, lungs etc.).

Enema. Liquid preparation introduced into the rectum.

Enteritis. Inflammation of the intestines.

Enterotoxaemia. Haemorrhagic enteritis.

Eosinophil. Type of white blood cells.

Epidemic, epizootic. A sudden outbreak of disease in a relatively small area.
Epidural anaesthesia. Injecting an anaesthetic into the canal of the backbone.
Epsom salt. Magnesium sulphate.
Erythrocytes. The red cells of the blood.
Estrus, Oestrus. Heat.
Etiology. Aetiology. The cause of a disease.
Expectorant. Substance to remove fluid from the lungs and trachea.
Expiration. Breathing out.
External parasite. Parasite that lives on the surface of the body (on the skin, in the skin, in the ears etc.).
Faeces. Feces, dung.
Fetus. Foetus.
Fever. Increase in the body temperature; an abnormally high body temperature.
Firing. Application of a red hot iron to the skin (Branding).
Flatulence. Excessive gas formation in the digestive tract.
Foetus, fetus. The developing young calf in uterus.
Fomentation. Application of a warm, moist substance such as a wet cloth to ease pain and inflammation.
Foreign body. Any object not normally found in the body.
Fracture. Breaking of a bone.
Fungus, fungi. A group of microorganisms, some of which cause diseases.
Galactagogue. Substance that promotes milk flow.
Gangrene. Death of body tissue.
Gas oedema. Blackquarter.
Gastroenteritis. Inflammation of the stomach and intestine.
General anaesthesia. Giving an anaesthetic to make the animal lose consciousness and not feel pain anywhere in the body.
Gestation period. The time from conception to birth; it varies from species to species (about 387 days in camels).
Gestation. Period of pregnancy, term of life of embryo/foetus within the uterus.
Ghee. Clarified, semi-fluid butter made from milk (common in Indo-Pakistan).

Giemsa. A dye lo stain blood samples used lo check for blood parasites.

Gland. An aggregation of cells that secrete or excrete materials.

Glomerular filtration rate. The speed at which the kidney filters waste products.

Glucose. Table sugar.

Goitre. Enlargement of the thyroid gland caused by iodine deficiency.

Gram-positive. Types of bacteria that are coloured deep purple in Gram's method.

Haematocrit. The volume percentage of red blood cells in the whole blood.

Haematoma. A swelling filled with blood,

Haematuria. Blood in the urine (Red urine).

Haemoglobin. Protein found in red blood cells.

Haemolysis. Destruction of the red blood corpuscles and the consequent escape of haemoglobin.

Haemorrhage. Bleeding.

Haemorrhagic disease. Disease caused by *Bacillus cereus* bacteria.

Haemorrhagic enteritis. Disease caused by *Clostridium* bacteria .

Haemorrhagic septicaemia. Disease caused by *Pasteurella multocida* bacteria (HS).

Heart. Organ in the chest that pumps blood around the body.

Heat. The time when the female accepts the male for mating and can become pregnant.

Helminthiasis. Disease caused by worms.

Heparin. A substance that stops blood from clotting.

Hereditary. Characteristics passed from parents to offspring.

Heritability. That which may be inherited; the capacity of being transmitted from one generation to another; the hereditary or genotypic variance expressed as a percentage of the total variance in the feature being examined.

Hernia. The abnormal protrusion of the intestines through the peritoneum, or part of another organ through the membrane or muscle that contains it.

Heterosis. (Also referred to as hybrid vigour) the effect achieved in a two species or two breed cross by which the values of a trait in the offspring exceed the simple mean of that of the two parents.

Hormones. Chemicals formed by glands in the body; they control the activity of organs.

Hybrid. An animal resulting from a cross between animals not taxonomically very close, are often infertile or subfertile in one or both sexes.

Hydatid cyst. Fluid-filled sac with young tapeworms in it (Hydatid disease).

Hygiene. The science of health and its preservation.

Hygroscopic. Said of something which takes up and retains moisture from the surrounding air.

Hyperglycaemia. Having very high levels of glucose.

Hyperplasia. Excessive growth of tissue or an organ.

Hypnotic. Induces sleep.

i.m. Intramuscular.

i.v. Intravenous.

Immersion oil. Oil used to examine objects under a microscope using a special lens.

Immune response. Reaction of the body to an antigen: production of antibodies that fight a disease causing organism.

Immune. Resistant to a disease due to the formation of antibodies.

Immunity. Body's defence against disease; can be passed to offspring through colostrum or through exposure, vaccination or inoculation.

Incision. Cutting the skin or tissue.

Incisors. Flat teeth at the front of the mouth.

Infection. Disease caused by microorganisms.

Infectious. Caused by infection, able to cause infection.

Infertile. Not able to reproduce.

Infested. Over-run by large numbers.

Inflammation. The reaction of living tissues to injury, infection or irritation; characterised by pain, swelling, redness and heat.

Infusion. Herbal medicine made by adding water to plant ingredients in a pot, covering, and allowing to stand, usually for about 15 minutes. An infusion can be either hot or cold.

Injection. The forcing of liquid into a part of the body (e.g. under the skin, into the vein or muscle).

Inoculation. Introduction of disease causing microorganisms or other material to stimulate immunity.
Insecticide. Chemical that kills insects.
Internal parasites. Parasites that live inside the body.
Interstitial. Spaces between individual cells or tissues.
Intestines. Part of the digestive tract between the stomach and anus.
Intracellular. Within a cell.
Intramammary. Into the udder, **Intramuscular, i.m**. Into the muscle.
Intravenous, i.v. Into the vein (vessel that carries blood towards the heart).
Iodine deficiency. Shortage of iodine in the body.
Iris. The coloured part of the eye.
Jaggery. A palm sugar made in some Asian countries.
Joint ill. Navel ill.
Joint. The point where bones meet (e.g. the knee).
Jugular vein. Large blood vessel in the side of the neck.
Karyotype. The appearance (size, shape and number) of the set of chromosomes of a somatic cell.
Keratitis. Inflammation of the cornea.
Kidney. Pair of internal organs that filter wastes from the blood and produce urine.
Kumri. Camel disease in Indo-Pakistan, causing shivering of the back legs (Myopathy).
Lactation period. The period of time (in days, weeks or months) during which a female animal gives milk.
Larva, larvae. Immature stage in the life cycle of an insect, maggot, caterpillar.
Larynx. Voicebox.
Latent heat of evaporation. The quantity of heat required to change a liquid to a vapour without a change in temperature.
Lateral recumbency. Lying on the side.
Laxative. Substance that encourages defaecation.
Leeches. Segmented worms, some of which suck blood.
Lesion. Alteration of skin or other body parts due to disease or injury.
Libido. Sexual, desire; the expression of sexual interest by male animals.

Liniment. A medicated liquid, usually containing alcohol, camphor and an oil, applied to the skin to relieve pain or stiffness.

Liver. Large, reddish-brown organ that secretes bile and is important in digestion.

Lobulated. Having lobes (as opposed to being smooth).

Local anaesthesia. Applying an anaesthetic only to a part of the body to stop pain in that part; the animal remains conscious.

Lockjaw. Tetanus.

Lower respiratory tract. The lungs and pleura (the membrane that lines the chest cavity).

Lung. Pair of organs in the chest that take in air, used for breathing.

Luxation. Dislocation.

Lymph node. Solid lump on lymph vessels which helps to protect the body against disease.

Lymphadenitis. Inflammation of lymph nodes.

Lymphocyte. Type of white blood cells.

Maggot. The larva stage of a fly.

Malnutrition. Poor nutrition caused by an inadequate or unbalanced diet.

Mandible. The bone of the lower jaw. **Mange**. Skin disease caused by mites.

Mastitis. Inflammation of the udder.

Membrane. A thin layer of tissue that covers a surface or lines a cavity.

Metabolic rate. The speed of or intensity at which the sum of physiological processes take place.

Microorganism. Very small organism, microbe, that can be seen only using a microscope. Microorganisms include bacteria, fungi, viruses and protozoa. Microorganisms that cause diseases are called pathogens.

Milk scours. Calf diarrhoea.

Milk teeth. Temporary teeth.

Millennia. For thousands of years.

Mites. Small parasites found in the skin, coat and ears.

Molars. Cheek teeth.

Monocyte. Type of white blood cells.

Morbidity. The incidence of disease; suffering from a disease.

Morphological characteristics. The outward appearance of an animal (colour, shape, size etc.).

Motility. The amount of movement of sperm.

Mucous membrane, mucosa. Membrane lining the respiratory and digestive tracts and other parts of the body. It secretes mucus.

Mucus. Slimy material formed to protect parts of the body.

Mycosis. Disease caused by fungus.

Mycotic. Caused by fungus.

Myiasis. Strictly speaking means ‘infestation with fly maggots’ or larvae; (nasal bots) often used loosely for other problems caused by flies.

Myopathy. A disease affecting the muscles.

Narcotic. A drug, which, in moderate doses, alleviates pain, reduces sensibility, produces sleep; in large amounts, induces stupor, coma or convulsions.

Nasal bots. Fly maggots living in the back of an animal's nose.

Nausea. Upset stomach, tending to vomit.

Navel ill. Infection of the navel cord in newborn animals.

Navel. Umbilicus, belly button, where the umbilical cord is attached during gestation.

Necrosis. Death of tissue.

Nematodes. Roundworms (internal parasites.

Nerves. Fibres that carry messages between the brain and other parts of the body.

Neutrophil. Type of white blood cells.

Nictitating membrane. The third eyelid.

Nomadism. A system with no fixed base but which wanders seasonally and in the longer term in search of feed and water resources. See also transhumance.

Nutrient. Nourishing substance.

Nymph. Stage in the life of an insect, after the larva stage.

Oedema, edema. Abnormal accumulation of fluids in the tissues.

Oesophagus. The tube that goes from the mouth to the stomach.

Oestrus, estrus. heat.

Omasum. Third stomach of a ruminant.

Open fracture. Broken bone that damages the muscles and tissue around it and pierces through the skin.

Oral. Belonging to, or taken through, the mouth.

Orf. A disease caused by a virus.

Otitis. Ear infection.

Ovary. The organ of a female animal that produces the egg or ova.

Ovulation. The discharge of eggs from the ovary.

Packed cell volume (PCV). Haematocrit. The proportion of blood plasma occupied by the cells of the blood; low PCVs indicate anaemia and a diseased state.

Pancreas. Internal organ that secretes fluids into the intestine and blood, and is important in digestion.

Pandemic. An outbreak of disease occurring over a very wide area, affecting a large percentage of the population (see also epidemic).

Paralysis. Inability to move a muscle or group of muscles, often coupled with loss of sensation in the affected urea.

Parameters. A factor or characteristic; a measurement or an item being measured.

Parapox. Orf.

Parasites. Organisms which have a harmful effect or cause a disease; usually refers to worms, ticks, fleas, mites, lice, leeches etc.

Parenteral administration. A method of giving medication that is not through the digestive tract (e.g. by injection).

Parity. The rank of a birth in the career of a breeding female.

Parturient. Giving birth or pertaining to birth.

Parturition. The act of giving birth; calving.

Pasteurellosis. Haemorrhagic septicaemia.

Patella. Kneecap.

Pathogen. Something that causes a disease, especially a microorganism.

PCV. Packed cell volume.

Pedestal. A camel's chest pad.

Pelvic. The area around the anus and the hips.

Penis. Male organ used in urinating and mating.

Peristalsis. Movement caused by a slight expansion of the diameter of an organ coupled with a shortening in length followed by a vigorous contraction in the opposite direction that result in movement and mixing.

Peritoneum. The membrane that encloses the internal organs (stomach, intestines, liver, spleen, pancreas).

Periurban. Around or close to towns or cities.

Pesticide. A poison used to destroy pests of any sort.

Physiological parameters. Those parameters relating to the physiology of an animal.

Pica. Licking, chewing and eating of unusual objects.

Placenta. The sac inside which the foetus grows and is attached to the mother's uterus, through which it is nourished.

Plaster. A mixture of materials that hardens; used for immobilizing body parts.

Pleura. Membrane that lines the chest cavity.

Pleuropneumonia. Inflammation of the pleura and lungs.

Pneumonia. Inflammation of the lungs.

Pododermatitis. Inflammation of the skin of the foot.

Polyoestrus. Having more than one oestrus cycle.

Post-mortem. After death; examination to discover the cause of death.

Post partum. After a birth.

Poultice. Soft, usually heated, preparation spread on a cloth and applied to a sore or inflammation.

Pox. A disease caused by a virus.

Predator. Animal that eats other animals.

Pregnancy. The development of the young inside the mother.

Prehensile. Capable of grasping.

Premolars. Cheek teeth in front of the molars.

Prognosis. A forecast on the probable outcome of a disease; the prospect for recovery. May be favourable, guarded, or unfavourable.

Prolapsed rectum. The lower portion of the intestinal tract (the rectum) comes out of the anus.

Prolapsed uterus. The uterus descends into the vagina and may be seen at the vaginal opening.

Prophylactic. Preventing disease.

Protozoon, Protozoa. Microorganism consisting only of one cell. Some protozoa (e.g. trypanosomes) cause disease.

Puberty. The time of sexual maturity, when an animal becomes capable of propagating its species.

Pulmonary. Pertaining to the lungs.

Purgative. Causing evacuation of dung from the intestines.

Pus. A whitish fluid produced by inflamed tissue and infected wounds.

Quarantine. Keeping sick animals separated from healthy ones for a certain period.

Rabid. Having rabies.

Rabies. A dangerous disease caused by a virus.

Radiation. Energy given out in the form of heat.

RBC. Red blood cell count: measure for the number of red blood cells in the blood.

Rehydration. The restoration of water to a body.

Reciprocal cross. Reverse cross in a two species (or two breeds) breeding programme; for example the donkey male–horse female cross produces the mule, whereas the less common *Reciprocal* horse male donkey female cross produces the hinny.

Rectum. The last part of the gut before the anus.

Recumbency. Lying down.

Repellent. Substance that repels or drives off other organisms, such as flies.

Reproductive tract. The organs involved in reproduction. In the female, the ovaries, uterus, vagina and vulva. In the male, the testicles, vas deferens (the tube leading from the testicles to the penis), prostate and penis.

Resistance. The natural ability of an animal to remain unaffected by noxious agents in its environment; the acquired ability of disease causing organisms to survive a chemical that normally kills them.

Respiratory tract. The organs involved in breathing. Includes the upper respiratory tract (nose, larynx, trachea and bronchi) and lower respiratory tract (lungs and pleura).

Retained placenta. A disease condition in which the placenta is not expelled after calving, requiring treatment.

Retention time. The amount of time that feed particles are kept in the stomach.

Reticulum. Second stomach of a ruminant.

Retina. The back of the eye which is sensitive to the light.

Retrospective survey. A survey in which owners or others are asked to remember what happened in the past e.g. the reproductive history of their animals.

Rhinitis. Inflammation of the nose.

Rift Valley fever. A disease caused by a virus.

Ringworm. A skin disease caused by a fungus.
Rumen. First stomach of a ruminant.
Ruminant. An animal (such as cattle, sheep, goats, buffaloes and camels) that has a stomach with four compartments (rumen, reticulum, omasum and abomasum). Ruminants regurgitate undigested feed from the rumen and chew it when at rest.
Ruminating. Chewing the cud.
Rut. The periodic sexual excitement of male camels (Rutting).
s.c. Subcutaneous.
Saddle gall or sore. Skin and tissue damage and abscess through badly fitted saddles.
Saliva. Fluid produced in the mouth.
Salmonellosis. Disease caused by bacteria of the genus *Salmonella*.
Sarcoptic mange. Mange.
Scabies. Mange.
Scalpel. Small surgical knife.
Sclera. The tough, usually white, outer coat of the eyeball.
Scrotum. The bag of skin around the testicles.
Secretion. Liquid produced by a gland.
Sedative. Drugs that reduce anxiety and make the animal easier to handle.
Septicaemia. The existence of microorganisms or poison in the blood.
Serum. The clear liquid that separates from the blood when it clots.
Sinus. Cavity; commonly refers to the cavities in the skull that are connected with the nasal cavity.
Specific agent. Remedy that has a special effect on a particular disease.
Spermatogenesis. The process of male gamete formation which results in the sperm.
Spermatozoa. The male reproductive cell, with a round or elongate head and a tail; the spermatozoa fertilize the ova shed by females.
Spinal canal. Hole running through the backbone. It contains nerves and liquid.
Spinal cord. The bundle of nerves located in the spinal canal.
Spleen. Internal organ that stores and cleanses the blood.
Splint. Pieces of wood put around a body part to keep broken bones in place.
Sporadic. An outbreak of a disease in a single or scattered location.

Spore. The inactive but infectious form of some bacteria (e.g. clostridium); the reproductive form of some fungi and blood parasites.
Sprain. A violent and sudden twist of a joint or muscles.
Staphylococcus. A type of disease causing bacteria.
Sterile. Free from living germs; not fertile.
Sternal recumbency. Lying on the chest.
Sternal. Pertaining to the breast bone (sternum).
Stimulant. Increases or hastens body activity.
Stocking rate. The number of animals actually kept on a given area (see carrying capacity).
Stomach tube. Long tube inserted into the mouth and used to put liquids directly into the stomach.
Stomach. The main organ where feed is digested. In ruminants, the stomach consists of four compartments: the rumen, reticulum, omasum and abomasum.
Stomachic. Stimulates activity of the stomach.
Stomatitis. inflammation of the mouth,
Streptococcus. A type of disease causing bacteria.
Streptothricosis. Dermatophilosis.
Stringhalt. Dislocated kneecap.
Styptic. Stops bleeding with an astringent.
Subcutaneous, s.c. Under the skin.
Substrate. The base on which an organism lives; a substance acted on chemically by an enzyme.
Surra. Trypanosomiasis.
Suture. Stitch, stitching.
Symbiotic. Said of the relationship of two kinds of organisms living close together and from which both derive benefit.
Symptom. Functional evidence of disease or of a patient's condition.
Syndrome. The collection of symptoms associated with a particular disease.
Synergistic. Said of an action or relationship between two or more organisms whereby the end result is greater than would have been achieved by each acting separately.
Systemic. Pertaining to or affecting the body as a whole.
Tabanid. Type of biting fly.

Tar. A dark-brown or black, viscid liquid obtained from various pine-tree species or from bituminous coal.
Taxonomy. The science of classifying living things, animals and plants according to their relationships with other organisms.
Tendon. The end of a muscle which attaches it to the bone.
Testicles, testes. The male reproductive organs, in which the sperm grow.
Tetanus. A disease caused by *Clostridium tetani* bacteria.
Third eyelid. The nictitating membrane: a fold of the conjunctiva.
Tick. Type of external parasite.
Tincture. Alcoholic extract of a plant drug.
Tonic. Produces healthy muscular condition and reaction.
Torticollis. Torsion of the neck, wry neck,
Tourniquet. A tight rope or bandage, used to restrict blood flow.
Trachea. Windpipe between mouth and lungs.
Tranquillizer. A medicine that calms or quietens an anxious patient.
Transhumance. Seasonal movements of livestock from and to a fixed base: strictly speaking the term should be (but rarely is) restricted to vertical movement between mountain summer and lowland winter pasture areas.
Trocar. A pointed, needle-like instrument equipped with a cannula; used to puncture the wall of a body cavity to withdraw fluid or gas.
Trypanosomiasis. Disease caused by trypanosome parasites.
Tsetse. Type of fly transmitting trypanosomiasis.
Tumour. An unusual growth in the body.
Turgidity. Swollen, thick or extended.
Tympany. Excessive gas, bloat.
Typology. An analysis of types; the results of such an analysis.
Ulcer. Inflammation or sore on the skin or mucous membrane, discharging pus.
Umbilical cord. Navel cord.
Umbilicus. Navel.
Ungulate. An animal with hooves.
Upper respiratory tract. The nose, larynx (voicebox), trachea (windpipe) and bronchi (air passages leading to the lungs).
Uterus. Womb, the organ inside a female where the young develops,
Vaccination. Applying a vaccine.

Vaccine. A preparation of killed, living inactivated or living fully infective microorganisms, especially viruses or bacteria, used to produce or artificially increase immunity to a particular disease. The process of administration, usually but not invariably by injection, is known as vaccination.

Vacutainer. Special tube used to collect blood.

Vagina. The portion of the female reproductive tract through which the baby animal must pass. It is separated from the uterus by the cervix.

Vermicide. Substance that kills worms or intestinal parasites.

Vermifuge. Substance that expels the worms or intestinal parasites; anthelmintic.

Verminous. Pertaining to, or due to, worms.

Vesicle. A small sac containing liquid.

Virus. A tiny microorganism, which causes disease.

Vitamin. Natural substance essential to the functions of the body.

Vulva. The opening below a female animal's tail to which the urinary and reproductive tracts are attached, which swells at time of oestrus and more so at calving time,

WBC. White blood cell count: measure for the number of white blood cells in the blood.

Wolf's tooth. First premolar on each side of the upper and lower jaw.

Womb. Uterus.

Wry neck. Camel disease causing the neck to be bent into an S-shape.

Zoonosis. A disease that is transmissible from animals to man.

(Wilson, 1998 and K. Rollefson *et al*., 2001).

ANNEXURE

RESULTS OF THE WORKING GROUP DISCUSSIONS HELD AT THE INTERNATIONAL WORKSHOP ON RESEARCH AND DEVELOPMENT TO FORMULATE RESEARCH AGENDA FOR THE NEXT DECADE (WAD MEDANI, GEZIRA STATE, SUDAN, DECEMBER, 2002)

These results have been published in the proceedings of the above said workshop by H.J. Schwartz (ed.) (2003).

Excerpts of Editor's Comments: It was the general consensus that there has been a slowly increasing volume of published research on camels in the past decade, but this is not satisfying the needs arising from the increasing importance of the camel as a food animal and income earner. Due to the fact that camels are usually raised and exploited under the most marginal conditions in remote areas, there is only minimal research conducted, which is production related.

In a recent literature search conducted by the editor, some 320 articles on camels were found in refereed journals between 1991 and 2001. Less than 10% of those were in some way production oriented. Most of the remainder were dealing with physiological, biochemical and camel health case studies. Common to this type of research is that it is conducted with very small numbers of animals and in laboratories, experimental farms or other artificial environments.

The critical observer can also find out a certain preoccupation with modern high-tech methods (e.g. embryo transfer and genetic manipulation), which are economically irrelevant to a sector of the livestock industry, which is only just developing market integration in many countries where camels are raised. We still are not certain, which factors cause seasonality of breeding in camel or whether reputed breeds are indeed breeds in the true sense.

Consensus was developed in the workshop that promotion of interest in production oriented research is much needed both within the scientific community and research funding agencies. Keeping the same in view,

research topics were identified in the five working groups (given in Table 1) and listed in more detail in the summaries provided by the working group recorders.
The same have been reproduced as such in this book for the benefit of all those interested in raising camels or conducting research on them.

TABLE 1: Broad categories of research topics and/or items identified in the working groups

Working Group	Topic / Item	
Nutrition and Management	1	Nutrient requirements and feeding standards for all classes of animals
	2	Evaluation of available feeds and forages
	3	Grazing systems and resource utilisation patterns
	4	Reproduction and reproductive efficiency
	5	Production systems and system performance milk
	6	Production systems and system performance meat
	7	Working performance (draught, loading, riding, leisure)
Breeding and Genetics	8	Breed identification and genotype description
	9	Investigate genetic base of productivity parameters
	10	Improved reproductive efficiency
	11	Methods and programmes for breed improvement
	12	Conservation of genetic diversity
Camel Health	13	Production (intensification) related diseases
	14	Environmental change related diseases
	15	Ethno-veterinary (traditional) medicine
	16	Food safety and (hygienic) product quality
	17	International and public health issues

Camel Products	18	Quality and processing of milk
	19	Quality and processing of meat
	20	Product marketing and consumer preferences
	21	Added value products (by-products) .
Socio-economics	22	Social integration of camel production systems
	23	Economic importance and function
	24	Production economics
	25	Market structures and development

SUMMARIES OF THE WORKING GROUP RESULTS

Working Group I: Nutrition and Management

- Research needs and potentials were discussed separately for two production system types:Extensive systems, i.e. traditional subsistence systems which are entirely based on natural pastures, with little or no market integration, usually migratory and opportunistic and based on communal land use with no established individual land use rights,
- Semi-intensive and intensive systems, i.e. market oriented systems,either integrated with cultivation, commercial activities and/or based on privately owned land; usually sedentary with access to supplementary feeding.

Research on improved nutrition and feeding for extensive systems:

- Strategic supplementation to include: feed banks for easily digestible energy and deficient micro-nutrients.
- Multiple species grazing system to study selective grazing behaviour of different domestic herbivores, set proper stocking rates for different range conditions.Toxic elements in feed and anti-nutritive factors.
- Support of migratory systems
- Provide feed and water (animals go to feed or feed taken to animals).

Research on improved nutrition and feeding for semi-intensive systems

- Establish nutrient requirements for various age groups and productive stages
- Develop feeding standards for different use classes - milk, meat, draught, riding and load carrying
- Evaluation of common feedstuffs and forages used by camels

Research on improved management

- Improve reproductive efficiency (improve conception rates, manage seasonal breeding,

reduce post natal mortality, reduce calving intervals, increase life time performance of female breeding stock)

- Develop feedlot systems to finish immatures for meat production, study compensatory growth effects
- Improve milk production and hygiene
- Optimise grazing management for more efficient and benign land use (rotational grazing, range improvement, develop feed banks and forage conservation)
- Develop improved harnesses and equipment for work camels

Research and development priorities

1. Develop supplementation systems (extensive and semi-intensive)
2. Reduce calf mortality
3. Increase milk production and improve processing
4. Develop sustainable multiple-species grazing systems

Working Group II: Genetics and Breeding

The major objective of research in genetics and breeding of camels is to improve animal performances to make more efficient use of the camels, unique adaptation to arid and semi-arid conditions and marginal feed and water supplies. At present there are only few reliable data to support systematic breeding for higher performance.

It is therefore suggested to embark on a programme of breed (type, ecotype etc.) identification and description of regional and/or local camel populations to:

- determine genotypic and phenotypic characters
- determine the differences in production and reproductive performances
- determine the differences in disease tolerance
- determine breeders perception and preferences
- determine management or husbandry requirements

Methods of identification of the genotype and phenotype characteristics can include:

- Classical (conventional) methods whereby breeds can be identified according to ethnic origins (of the breeder), location, phenotype, size, colour and/or prevalent use (milk, meat, work etc.)
- Molecular-biological methods such as RAPD (randomised amplified polymorphic DNA-fingerprinting), micro-satellite DNA to determine the location

of the gene and the products. PCR (polymerase chain reaction detection assay), or DNA sequencing

Determination of performances will require extensive data collection and recording of:

- reproductive traits such as age at puberty, sexual maturity, and at first calving, length of gestation period, calving interval, conception rate, rate and cause of abortions etc. and of
- production traits such as birth rate and weight, weaning rate and weight, post natal mortality, mature weight, growth rate, milk yield, lactation length, productive life span as well as other performance characteristics (work capacity, wool and hair production, racing performance, medical properties of camel products etc.)

Development of breed improvement programmes will comprise of:

- Estimation of breeding value for different utilities such as preferred phenotype, performance (milk, growth, fertility, work capacity etc.)
- Choice of the system of breed improvement, i.e. within-breed selection or various crossbreeding schemes
- Choice of breeding techniques, i.e. natural mating, artificial insemination, embryo transfer or other advanced biotechnological methods

Conserving present genetic diversity in the world's camel population requires either:

- In-situ conservation of breeds within the production system or
- Ex-situ maintenance of live breeding groups outside the production system (zoos, parks, experimental farms, enclosures)
- or cryo-conservation (semen, embryos, somatic cells)

Working Group III; Camel Health

The group identified several different health related complexes which are treated separately.

I Diseases of intensification / diseases of production effects in camel

Brucellosis, mastitis, camel calf mortality, respiratory diseases, reproductive disorders, skin diseases, helminthoses (incl. schistosomosis), ticks and tick-home disease (TBD)

Hypothesis 1: With increased intensification increase in disease incidence

Hypothesis 2: With increased intensification disease patterns will change

Expected favourable conditions:

- Under more intensive management better access to data
- Possibility of sentinel herds
- Improved monitoring

Country	**Research capacity/ potential (low, moderate, high)**	**Research priority (low, moderate, high)**
Sudan	Moderate	Low

Somalia	Low	Medium
Kenya	Moderate	High
Pakistan	Moderate	High

II Changing camel disease patterns with changing ecological conditions

Camel systems will experience environmental changes due to man-made agricultural schemes and due to displacement of pastoral systems by other more intensive forms of land use. This will lead to new research topics:

- monitoring newly emerging diseases
- Effects of stress on immunological status of camel
- Changes in endemic/enzootic stability
- Disease transmission dynamics within species and across species (trypanosomiasis, brucellosis etc.

Country	**Research capacity/ potential (low, moderate, high)**	**Research priority (low, moderate, high)**
Sudan	High	High
Somalia	Low	Low
Kenya	Moderate	Moderate
Pakistan	Moderate	High

Ill Ethno-veterinary medicine / indigenous knowledge in camel keeping societies

Research areas are:

- Taking stock of application and potential of herbal medicine
- Identification and assessment of indigenous practices, practitioners, and knowledge
- Identification / classification of diseases by camel herders as prerequisite for surveillance
- Application and validation of methods of participatory epidemiology

Country	**Research capacity/ potential (low, moderate, high)**	**Research priority (low, moderate, high)**
Sudan	Moderate	Moderate
Somalia	Moderate	High
Kenya	Moderate	Moderate
Pakistan	Moderate	Moderate

IV National and international issues with regards to camel in animal health

Specific fields are freedom from disease, control of trans-boundary diseases and disease surveillance. Research areas are:

- Development of an adapted, epidemiologically sound sampling frame in nomadic-pastoral production systems
- Herd health monitoring and surveillance systems
- Refining disease detection methods
- Testing procedures
- Test protocol
- Involvement of all stakeholders along the production chain (particularly traders)
- Data collection and decision support research for international discussion in the various organisations and committees (OIE, FAO)

With regard to food safety specific fields are product quality and veterinary public health. Research areas are:

- Residues in meat and milk (pesticides, drugs)
- Application of HACCP and risk analysis to meat and milk all along the food chain
- Use of milk in alternative medicine
- Hygiene and consequences of raw liver consumption in Sudan
- Risks associated with by-products (e.g. hides) and monitoring of non-` pasteurised camel milk
- Feasibility study in acceptance of camel food products (minced meat, sausage, intestines, ..., ice cream)

Country	**Research capacity/ potential (low, moderate, high)**	**Research priority (low, moderate, high)**
Sudan	Moderate/high	High
Somalia	Moderate	High
Kenya	Moderate	High
Pakistan	Moderate	High

Working Group IV: Camel Products

Research Agenda for Camel Milk Production / Processing / Marketing

Unlike Kenya and Somalia, Sudan does not have established camel milk markets. The same applies also to a slightly lesser degree to Syria and Pakistan. Therefore the following points are of specific importance, before considering research programmes relevant to improve camel milk production and marketing that are listed below:

- identify production areas with camel milk marketing potential estimate regional production surplus,
- introduce the concept of milk marketing to relevant camel milk producers,

- create consumer awareness on medicinal and nutritive value of camel milk, develop and test mobile collection and mobile processing strategy

Research priorities relating to camel milk

- Development and validation of camel milk quality tests
- Defining and evaluating quality standards for camel milk
- Analysis (HACCP) and participatory assessment of traditional & current practices to develop an adapted hygiene concept for camel milk
- Test possibilities to expand the shelf life of camel milk at the production level (Lactoperoxydase, heat)
- Examine the effect of Lactoperoxydase (LPS) and heat treatment on medicinal and nutritional properties of camel milk
- Develop and test simple small-scale camel milk processing methods / technology
- Diversify camel milk products (fermented milk, ghee and storable products)
- Investigate consumer demand and preferences
- Assessment of physical / chemical / organoleptic properties of camel milk under various environmental and physiological conditions

Research Agenda for Camel Meat Production / Processing / Marketing

Research on camel meat is an absolute priority for the Sudan, where export of slaughter camels through traditional marketing channels is well established. The emergence of new markets for quality camel meat (Saudi-Arabia, Egypt) should be monitored.

- Identification of new marketing channels for quality camel meat / new camel meat products
- Promotion of camel meat as a healthy product and assessment of consumer acceptance and consumer preference for quality camel meat / new camel meat products
- Study the current practice and acceptance among pastoralists for marketing of male camel weaners / young male camels
- Diversification of camel meat products (sausages/dried meat/burgers), application **of** standard cuts, vacuum packaging, meat hygiene and meat quality standards
- Assessment of optimum slaughter age / weight and carcass characteristics with regards to camel meat quality

Research Agenda for Camel Wool / Hides / Bones / By-Products

Wool: improve traditional methods through introduction of low-tech processing equipment

Hides/Bones/By-Products: no research priority at present.

Working Group V: Socio economics

General

- Socio-economics research is neglected in agricultural and livestock research in general, and in camel research in particular.
- Any research and development efforts should make people, in this case pastoralists, at the centre.

- Camel is an efficient utiliser of resources in marginal areas which otherwise may not be utilized efficiently

Research issues identified by the group

I. Social issues

- Social integration of camel pastoralists into the main social system
- Sustainability of tribal/group pastoral system and the need for community based services
- Human-animal-environment relationships: nomadism/semi-nomadism; partial settlement/agro-pastoralism systems and their interaction with population and environment
- Socio political role of pastoralists (local administration & governance)
- Social development of pastoralists health, education, income, employment and livelihood security.
- Women's participation and role in camel pastoralism (milk processing, milk marketing, wool processing etc.)

II. Economic importance & function

- Food (milk, meat)
- Wool (tents, ropes etc), skin & hides (saddles, carpets etc.)
  Income contribution (GDP, exports, wage and revenue)
- Draught power contribution (transports, traction, riding, etc.)

III. Production economics

- Optimal herd size & composition
- Adoption and impact of improved animal/crop production technology in camel-based pastoral system, cost-benefit analysis
- Processing & promoting animal products
- Resource use & environment protection
- Marketing issues: marketing costs, market information, marketing system efficiency (e.g. ethical aspects of brokers & traders), market infrastructure, export promotion, instability of price and marketed volume of animals and animal products
- Policy issues and studies: sedentarization vs. nomadism/semi-nomadism, rights to grazing lands & water points/sources, extension policy for pastoralists, credit/finance policies

IV. Research agenda

- Justification: the camel sub sector is important in terms of economic and social roles and contributions.
- Objectives: To improve performance of camel sub sector in order to provide a better quality life for the community and to increase its contribution to the economy.

V. Research areas

1) Exploring the socio-economic importance of the camel sub-sector**.**

Social aspects

- Social role of camel in community
- Gender aspects in camel sub-sector
- Social situation of pastoralists

Economic aspects

- Economics roles of the camel sub-sector
- Contribution to GDP
- Contribution to exports
- Contribution to employment
- Contribution to household income
- Provision of food
- Provision of raw material for industrial and non-industrial uses

2) Production & productivity

- Input-output relationship in camel and camel production
- Competitiveness of camel sub-sector (e.g. Profitability & resource use efficiency)
- Optimisation of herd size and composition

3) Policy studies

- Export policy
- Taxation policy
- Credit policy
- Extension policy
- Environment policy
- Grazing & water rights policies
- Issue of sedentarization versus nomadism

4) Marketing system efficiency

- Market structure, conduct and performance
- Market infrastructure
- Market information
- Analysis of demand for camel products
- Price studies (instability)
- Camel product processing & promotion
- Internal & external market integration

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